Convention Extra, May 15, 1927

Electrical West

With which is consolidated the Journal of Electricity

A McGraw-Hill Publication

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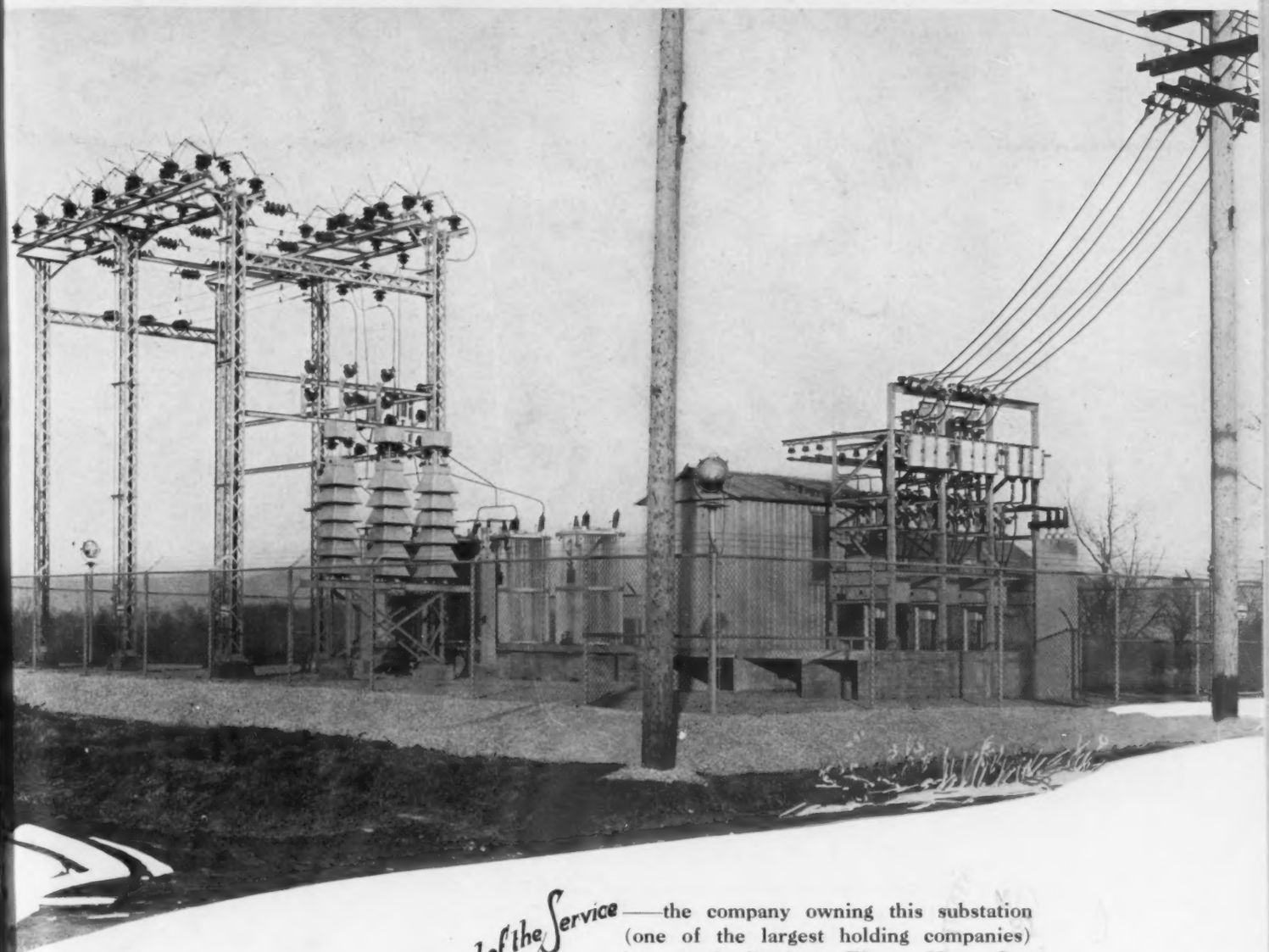

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Electrical West

With which are consolidated the "Electrical Journal," the "Journal of Electricity, Power & Gas," and the "Journal of Electricity"

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W. A. CYR, *Associate Editor*
G. R. HENNINGER, *Associate Editor*

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G. C. TENNEY, *Managing Editor*
E. K. JONES, *News Editor*
B. H. SNOW, *Northwest Editor*

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C. T. HUTCHINSON, Editorial Director
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Recording a Year's Progress of Two Associations

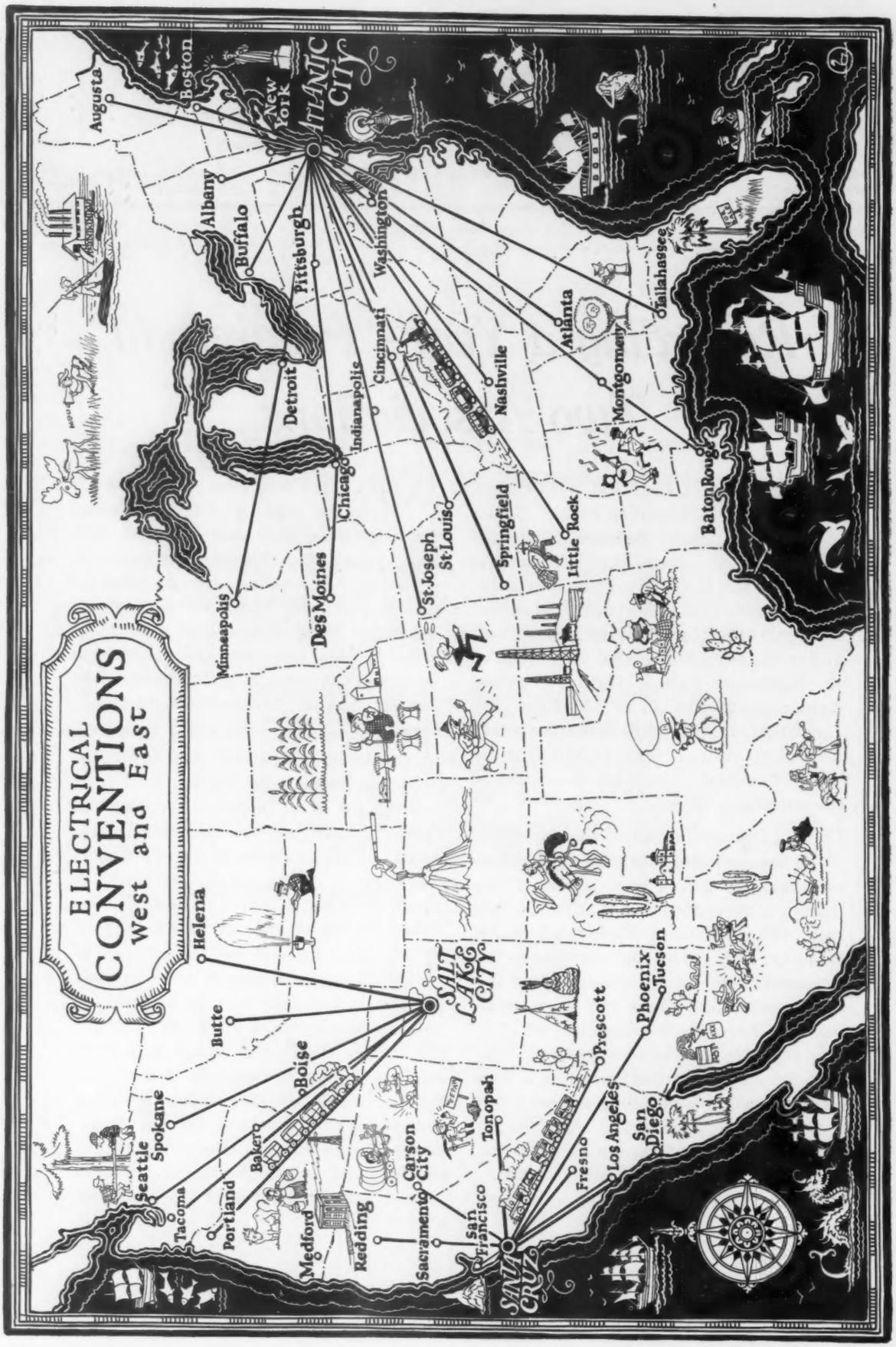
THIS issue of Electrical West carries the title, "Convention Extra." It has been so named because it contains the committee reports that will be presented at the eleventh annual convention of the Pacific Coast Electrical Association to be held at Santa Cruz, Calif., June 14-17, and at the twentieth annual convention of the Northwest Electric Light and Power Association to be held at Salt Lake City June 21-24. It is an extra in the sense that its date of issue is May 15 and that its editorial content is confined to reports of the committees alone.

THE "Convention Extra" idea is unique. In the first place, its staff of contributors numbers almost a thousand of the leading electrical men in California, Nevada, Arizona, Oregon, Washington, Idaho, Montana and Utah, and comprises the personnel of the various committees of the two associations. These men are specialists who have given generously of their time and effort for the advancement of the industry. The contributions cover a wide range of subjects including almost every phase of the generation, transmission, distribution and utilization of electrical power, as well as the allied subjects incident to so intricate and important a business.

WHILE the statement might be made that the majority of the discussions deal with the central station and its problems, nevertheless there is much in the reports that has a definite bearing upon the activities of every branch of the electrical industry. That there is something of value in this issue for every man and woman in the industry will be revealed by a careful perusal of the editorial content.

THE papers are published prior to the conventions at which they are to be presented because this practice affords an opportunity to all members to study the reports carefully so that they may be prepared to offer constructive discussion. Moreover, it brings the convention more closely to those members of both associations who are not able to attend.

THE men who have had the privilege of reviewing these papers prior to their publication feel that they present an accurate cross-section of the progress of the industry in the Western states during the past year. Our readers will benefit from the material presented in direct proportion to the time they devote to study of the reports. Those who do review the papers carefully will find themselves better fitted to keep pace with the progress of the industry.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SANTA CRUZ

"Progress Follows Light and Power"

—the Convention Theme

by

S. Waldo Coleman

President

Pacific Coast Electrical Association

S. WALDO COLEMAN

WE ARE living in an age of progress. An analysis of the factors which constitute largely present day progress finds electricity, as expressed in light and power, the torchbearer of that progress. The objective of the Pacific Coast Electrical Association is to aid the electric industry in being ready continuously to answer the call for leadership in the development of our country.

The growth of civilization has been made possible by the working together of various peoples striving for the same objective. The main purpose of an organization such as ours is to synchronize the efforts of those engaged in the electric industry so that there may be proper encouragement and team work that will insure the reaching of our objective with the maximum of efficiency. That objective is the making of life more convenient, more happy and more useful through the use of electric energy.

The increased use of electric energy has made not only for increased efficiency in our daily life, increased convenience in the home, but it has given more time for the pursuit of those cultural developments which mean so much in life.

The Eleventh Annual Convention of the Pacific Coast Electrical Association is to be held this year at Santa Cruz on June 14, 15, 16 and 17. The theme for the convention is an appropriate one, "Progress Follows Light and Power."

Proud as we may properly be of the record of the electric industry in the past, it is only by continually perfecting ourselves that we can maintain the leadership which we now have. The fundamental tone of the convention will be an educational one therefore. Our efforts during the daily sessions will be rewarded by a splendid program of entertainment in the evenings—not to mention the Golf Tournament which has been prepared by the entertainment committee.

The time of the convention gives those in the industry an opportunity to widen their circle of acquaintanceship and to develop closer friendships with others in the electric industry. There is nothing so inspiring, so helpful to our work, as this inspiration of a fellowship with men and women all working for the same purpose, that the electric industry in its growth shall be of greater and still greater value to mankind.

Advertising-Publicity Section[1]

The Advertising-Publicity Section of the P.C.E.A. for the year 1926-27 has had a very practical and profitable season. Four meetings were scheduled during the year, prior to those of the convention, two in San Francisco and two in Los Angeles. Attendance and interest of members have been highly satisfactory. Much information of importance to members has been presented and discussed.

Advertising-Publicity Business Activities*

From a business standpoint, the chief accomplishments of the section were the following:

Co-operated in a very satisfactory manner with the Advertising Committee of the Public Relations Section in carrying on a joint advertising campaign to tell the story of the power companies and promote a better feeling of understanding and goodwill on the part of the public toward the electrical industry as a whole.

Through its Standards Committee declared in favor of condemning all forms of illegitimate advertising; and in cases of unethical advertising within the industry, of writing the advertiser that such advertising is "not in line with the ethical practice and that it is hurting the industry as well as himself."

The printing and distribution of the section's "Book of Standards" prescribing the organization, procedure and standards of practice for the section and its members.

Enlargement of the section's activities to include participation of as many people as possible who are interested in advertising and publicity work of the industry, such as advertising agency men handling utility accounts, etc.

Offered the co-operation and assistance of the section to the other sections of the association.

Through its Information Committee distributed considerable information about the industry to school and college students and other such inquirers, but condemned the practice of some advertising agencies in trying to obtain information and material for advertising purposes, the supplying of which would require unusual and lengthy research on the part of the industry.

Recommended to the Public Relations Section that "serious consideration be given to the employment of a man qualified to speak to the public on utility matters and to generally direct the public relations work of the industry as represented by the association."

Sponsored a public speaking contest within the association, and a Tuesday luncheon meeting at the convention, at which the finals of a 3-minute speaking contest should be held, and arranged for a prize to the value of $125 for the winner. Arranged also for a Wednesday luncheon meeting at the convention with a speaker.

From the standpoint of information peculiarly valuable to advertising and publicity men, the section devoted each meeting to a particular study topic, which was presented first by speakers and then discussed from the floor.

* Report, **R. E. Smith,** Southern California Edison Company, Section Chairman.

The Use of Direct-Mail in Advertising*

The first of these study topics was "Direct Advertising" presented at the meeting of Sept. 10, 1926, in San Francisco, by Jean Blum, of Blum's Advertising Agency.

* Report, J. C. Jordan, Pacific Gas and Electric Company, Dept. Editor.

[1] **R. E. Smith,** Southern California Edison Company, chairman. **J. C. Jordan,** Pacific Gas and Electric Company, vice-chairman. **E. P. Ramsay,** Los Angeles Gas & Eelctric Company, secretary. **Electrical West:** W. A. Cyr. **Pacific Gas and Electric Company:** F. S. Myrtle. **San Joaquin Light & Power Corporation:** S. W. Green, A. C. Joy.

Some of Mr. Blum's important statements were:

As I understand it, electrical advertising aims at certain definite objectives in its respective fields.

In the industrial or business field, electrical advertising must "prove its case" as an economy factor before it can hope to receive favorable consideration. Its aspect must be technical, and its keynote must stress the labor-saving, time-saving and money element.

In the home field, which is the next largest consumer group, electrical advertising has manifold objectives, some of which are not very clearly defined.

In my opinion, in order to sell more electrical goods in the average home, it is necessary to go beyond the splendid type of educational advertising which is usually being done.

Here are a few of the objectives I believe such electrical advertising should aim at:

1. It should try to overcome prejudice. By that I mean the average woman's fear of danger—costliness of the appliance and the intricacies of handling it.

2. It should try, where possible, to overcome the mystery angle. By mystery I refer to a lack of taking the reader into confidence as to exactly how the appliance works, why it cannot get out of order easily, and similar information.

3. Electrical advertising for the home should stress, wherever possible, the economy of power consumption and lasting qualities of the featured appliance. Charts on the subject are more easily understood than long drawn out verbiage.

I am bringing out these points because it must be remembered that electrical appliances do not carry the same appeal to a woman as would wearing apparel, or home furnishings. She is not quite as receptive to electrical goods as she might be, therefore, convenience, time-saving, cleanliness, economy and lasting qualities are essential features.

Direct-mail concerns itself with the more important function of talking to and selling to a given list of potential customers. Its mission is that of turning passive interest created through all forms of advertising into actual sales. It co-ordinates, but does **not compete** with any form of advertising.

As an advertising medium direct-mail does not always justify its cost. As a sales medium, direct-mail is the most effective tool in modern **business.**

Here are some specific uses for direct-mail in electrical advertising, as they come to my mind:

From the manufacturer's side:

1. Before launching the advertising campaign, have some reprints made of all advertisements and mail to all dealers and prospective dealers. Take them into your confidence.

2. During the publication period of your advertising campaign, keep your dealer's interest alive by suggestion as to how to cash in on the value of the campaign.

3. Every ten days or two weeks after the publication of your advertising, send some sort of letter, card, or message to the retail outlets commenting upon the effect of the campaign, and suggesting means of developing sales for the product.

4. If at all possible, prepare a four-page illustrated letter featuring the particular product, leave the first page blank for imprinting your dealer's name, have a processed letter telling the consumer that the particular appliance is now on display at the particular dealer whose name appears on the letter-head, and mail to a selected list of the dealer's customers and prospects.

The jobber and the contractor should be taken into confidence by giving him a complete outline of the advertising campaign, its dates of publication, reprints of advertisements and suggested sales letters which are to be mailed to a definite list of prospects.

Dealer sales-promotion must be planned in advance. It is the most effective sales-tool that a manufacturer can employ. It is the most logical follow-up to any advertising campaign and usually results in increased sales.

Business people are interested in economical factors. A letter accompanied by a questionnaire relating to the prospect's particular problem, offering to make a survey without cost to the firm, will develop many leads for future installations.

In this type of direct mail it is best to limit the material to an informative nature. Eliminate sales-pressure—that had best come after the prospect shows the slightest interest.

The retailer must rely upon three distinct methods for the purpose of intensifying sales.

1. Personal salesmanship—both from within his store and by outside sales-people.

2. Direct-mail follow-up material supplied by the manufacturer—wherever he can secure such material.

3. Direct-mail material prepared by himself, or, if he is a large dealer, prepared by his advertising counselor.

How is the retailer to use direct-mail?

The most effective way is by mailing out letters and other material bearing upon the product to a list of his customers and prospects. Such material, if furnished by the manufacturer who will allow the dealer to vary his message on the letter-portion of an illustrated four-page letter, is usually the most desirable.

In the absence of such material, a dealer can prepare either letters, postcards, or folders, and mail to a list of his customers and prospects immediately after the publication of the advertising has taken place—thus tying in his store with the effect of the advertisements published.

He can print ordinary government postal cards briefly describing the article, and inviting his customers to examine it at his place of business.

If he is a new dealer and has not yet learned the value of building a mailing list of his customers and prospects, he can print a folder or broadside and have it distributed from house-to-house within a certain radius of his place of business.

Incidentally, very few retail electrical dealers appreciate the many advantages and economy of this form of sales promotion.

House-to-house distributing, properly done, reaches the best type of prospects—the housewife—who is the ultimate buyer.

Direct-mail which precede your salesman's personal calls effectively cuts down sales-resistance and acquaints your prospects with your product. In tests made by many large advertisers, it was found that direct-mail increases results from personal salesmanship from 20 per cent to as high as 80 per cent.

The ultimate objective of all good advertising is sales. Direct-mail bridges the gap between passive interest created by all forms of advertising and more sales. It "cashes-in" on the enormous percentage of good-will which is lying dormant as a result of your publicity efforts, and contacts directly with your known prospects.

It is an important adjunct to your sales-structure.

The Budget—Engraving—Typography*

At the second meeting of the section, held in Los Angeles Dec. 3, 1926, a "Behind the Scenes" program was carried out.

Under the heading of "Behind the Scenes in a Public Utility Advertising Department," J. C. Jordan, Pacific Gas and Electric Company, R. E. Smith, Southern California Edison Company and J. F. Pollard, Coast Valleys Gas & Electric Company, explained the mechanical routine of the advertising departments of their respective companies. Mr. Pollard then described at length how the 1926 advertising budget of his company, as representative of that of a smaller utility, was allocated. Local newspapers received 50.1 per cent, billboards 4.0 per cent, miscellaneous direct advertising 12.9 per cent, national and co-operative publications 8.9 per cent, contributions to local celebrations and booster advertising 17.6 per cent, community welfare organizations, 2.2 per cent, magazine and books of general circulation 4.3 per cent.

"Behind the Scenes with an Engraver" was next handled by R. L. Garnier, of the Garnier Engraving Company of Los Angeles. Mr. Garnier gave a very interesting and instructive discourse on the history and development of the engraving art and the processes it involves at the present tme. Of practical import in the intelligent use of engraving he gave the following advice in the use of the right screen for the right sort of paper:

60-Line Screen—For newspaper work where work is run from stereotype plates (curved plates).

85-Line Screen—For newspaper stock where work is run on high speed **flat bed** press.

100-Line Screen—For better grade of newspaper stock and cheap grade of book paper where work is run on press at lower speed than flat bed newspaper press.

120-Line Screen—For commercial, book and periodical printing where work is run on a fair grade of machine finish paper.

133-Line Screen—For fine catalog printing and all commercial work using a good grade of coated stock.

150-Line Screen—For the finest grade of work where the finest detail is required. The finest grade of paper must be used for this screen at all times and also the most careful handling in the press work is required.

"Behind the Scenes with the Typographer" was the subject of Henry Mayers, president of the Mayers Company, Inc., of Los Angeles. Mr. Mayer described in considerable detail the various stages an advertisement goes through from the time the copy is sent to the typographer until it becomes an electrotype, stereotype or a mat. The following "high-lights" are of interest:

1. **Preparation of Copy**—Should be neatly typewritten—cuts should be square—layout should accompany copy.

2. **Element of Cost in Typography**—Variety of measures, "run-arounds," mortises, fancy rules—corrections in spacing.

3. **Making of Electro**—Typographer's form is pressed in warm wax, which is covered with graphite and electro-plated with a copper shell which is then stripped from the wax, backed up with lead and wood mounted. A number of other minor operations—all very painstaking—highly skilled work.

4. **Making of Mat**—The electro is placed over a damp, spongy sheet of mat-paper and under enormous pressure an impression of the electro is made in this paper. They are put through further pressure and steaming to drive out all moisture and the mat is then complete. An electro must be used to make mat because the pressure and steam would ruin type-matter and cut, if original form were used.

5. **Making of Stereo**—A mat is placed in a "casting box" and molten stereo-metal (mostly lead) is poured against it. The mat acting as a mould, a duplicate of the electro is thus cast.

6. **Difference between Electros, Mats and Stereos**—The electro is the best printing plate because it is only one step removed from the original form, and every step away from the original loses something of its sharpness—particularly where halftone cuts are used. Small town papers will print direct from the electro furnished them. If furnished with a mat, they will cast their own stereo and run from that, and results will depend on their ability to make a good stereo. They are sometimes careless and should be warned when careful results are expected.

The metropolitan papers do not print from electros furnished them. They merely lock the electro up in a full newspaper-page form and make a full page mat from that. Then they cast a full page stereo (specially curved to fit their presses) and print from that stereo. If furnished a mat, the large newspapers will first cast a stereo from it, then go through all the above steps as with an electro. Thus giving a large newspaper a mat results in getting a final printing plate that is **five** steps removed from the original form—that is, has been given five opportunities to lose some of its original detail and sharpness.

* Report, D. L. Scott, Los Angeles Gas & Electric Corporation, Department Editor.

House Organs*

At the third meeting of the section, held in San Francisco Feb. 25, 1927, the study subject was "House Organs," discussed by J. P. Coghlan, assistant to the president, Pacific Gas and Electric Company, and E. F. O'Day, Spring Valley Water Company.

Mr. Coghlan told in considerable detail the history and purpose of the publications put out by his company:

"Pacific Service Magazine" was the first of these. It was begun in 1909 and was designed to and functions as a repository of the achievements, and record of the progress, of the organization. First intended as an employe publication only, it had an original circulation of about three thousand. It is now a quarterly magazine of a very high class supplied to many thousands of stockholders, as well as employes.

"P.S.E.A. News" was started second. It is a monthly put out by and for the Pacific Service Employes' Association, the company's employe organization. It is strictly employe in character; devoted to personals, association and company news, with correspondents in every district. Its circulation is six to eight thousand. It has been very effective in cementing the employes and their interests.

"P. G. and E. Progress" has been established only about three years. It is an entirely different type from the other two publications. It is issued monthly to more than 450,000 employes, stockholders and consumers, the latter forming the great bulk of the circulation. It is issued in newspaper style and contains articles about the company's activities which affect the growth and progress of the communities served. It has a household page to which women are invited to contribute. The publication has been very successful in telling the company's story and has been quoted many times over the country.

Mr. O'Day told the story of "San Francisco Water," the house organ of the Spring Valley Water Company. The magazine, a quarterly, was started five years ago to bring the stockholders into closer touch with the company's affairs and to weld the employes into a closer organization. The magazine goes to employes, stockholders, many members of the water works industry and a selected consumer list. Although the company is a small organization the publication has been so successful that its circulation has increased about 45 per cent since it was started. It is a policy, also, to send it to anyone interested enough to ask for it.

Considerable stress is laid in the magazine on the historical, and as the Spring Valley Water Company's activities date back to the 1850's, there is much valuable material available that is of intense interest to the people of the San Francisco district. There are articles in it by department heads. Controversial materials are not published, and an interesting feature is that there is nothing of a personal nature and no joke column.

Mr. O'Day gave his opinion that good printing and good engraving are prime requisites of a successful house organ. He also agreed with a speaker from the floor that the chief causes of the high mortality rate among house organs are (1) lack of a real need for the publication, (2) editorial incompetence, and (3) impatience to realize tangible results too quickly. In editing a house organ Mr. O'Day stated that one should use simple and clear language and methods of expression, but not "write down" to one's readers, "Don't preach; and be sure you know what you are talking about."

* Report, F. S. Myrtle, Pacific Gas and Electric Company, Department Editor.

Supplemental Advertising*

At the fourth meeting of the section, held in Los Angeles April 11, 1927, the study subject was "Supplemental Advertising," under which heading "Outdoor Advertising," "Advertising with Electric Signs" and "Street Car Advertising" were discussed by three different speakers.

* Report of department editor.

Outdoor Advertising

Outdoor advertising was handled by R. S. Montgomery, general sales manager of Foster and Kleiser Company, who told in considerable detail of the successful work of that company in 600 cities and towns of four Pacific Coast states.

"Advertising," he stated, "is the art of stating the truth attractively, done for the purpose of establishing confidence to the end that customers may be secured." He then outlined the attributes of the ideal advertising medium as (1) flexibility (adaptability), (2) circulation, (3) exposure, (4) repetition (size, color, poctorial appeal), and illustrated by a chart how, by reason of possessing these attributes, outdoor advertising is able to reach the largest percentage of people of any of the four chief classes of media—newspaper, direct, magazine and outdoor.

With miniature reproductions of some of the Foster and Kleiser boards, Mr. Montgomery then showed how effectively a community can be "covered" by the outdoor medium, describing in detail the care exercised by the company in checking traffic flow and location and other details that will insure circulation, visibility, attention value and attractiveness of the boards and painted displays.

Mr. Montgomery closed with the information that the outdoor medium, by virtue of the number of people it reached, was so comparatively inexpensive that it formed only 8 per cent of the total national advertising expenditure.

Electric Signs

Advertising with electric signs was discussed by Paul D. Howse, president, Electrical Products Corporation.

Mr. Howse traced the early history of illuminated signs and stated that the invention of the incandescent electric lamp began the development of electric signs as known today. It was a slow process, however, until more recent years, when the business has shot forward with remarkable rapidity as people began to appreciate the value of the electric sign. Witness the jump of electric signs in Los Angeles from 33 in 1912 to 11,000 in 1927.

Even today, though, electric signs did not have a daylight value until the present Neon sign was developed. With this came a full 24-hour value that has made electrical advertising more effective than ever, Mr. Howse stated.

He explained the system of leasing, not selling, the Neon signs, and told of the company's servicing and weekly inspection for clients which insures a constantly effective sign at comparatively small cost.

Mr. Howse concluded by citing the value and effectiveness of electrical advertising as experienced by a number of outstanding businesses.

Street Car Advertising

Street car advertising was the subject of a talk by Mr. Hannigan of the Pacific Railways Advertising Company.

He told of the beginning of street car advertising forty years ago on a single line in a small eastern city, and compared that with its widespread use today as indicative of its effectiveness.

Car cards have a mass appeal that is not suited to all types of advertised articles, Mr. Hannigan stated, and admitted also that, like every other medium, there is some waste circulation. But he stressed particularly the point that car card advertising is the least expensive medium in proportion to its circulation.

He stated that in Los Angeles, for instance, there are 1,300,000 cash fare customers riding the street cars every day, and that the average length of ride is 28 minutes. This indicates, Mr. Hannigan pointed out, the long period the car card message is before its readers as compared with advertisements in other media. He also showed how car cards are all out in the open—there are no "inside pages" for car cards.

Many large advertisers use car cards exclusively for their city advertising, while using magazines for the rural circulation. Many products, Wrigley's gum and Lifesavers, Mr. Hannigan stated, used car card advertising exclusively until the product was on a national basis.

The effectiveness of car card advertising can be brought out only by long time use, Mr. Hannigan concluded, whereby there is an enormous continuity value—a constant drip, drip, drip—enhanced by a fine color appeal.

Commercial Section[2]

General Committee Reports[3]

Plan of Reorganization of the Commercial Section*

Before proceeding to an analysis of the organization of the Commercial Section with a view to bringing more continuity into its program of work it may be well first to state definitely the primary objective of the section.

Our conception of this objective is that the section should bend its efforts to assist the commercial departments of the several member companies through the interchange of ideas, the discussion of experiences, the compiling of data and the joint study of mutual problems, directed always to the selling of more electric service and the building of more business, profitably.

These efforts will lead into the field of customer relations to the extent that good customer relations are not only essential before new customers are added and old customers are made bigger customers but are also essential in retaining the load and gross revenues that the central stations already enjoy.

Insofar as the selling of appliances is essential to the building of profitable electric load, it will lead the section very properly into a study of appliance merchandising.

It should not only be the function of the section to find and boost the activities in the several branches of the selling end of our business but it will be necessary for the section to investigate the feasibility and profitability of many proposed schemes and activities which it may be advisable to recommend against as being unprofitable business to develop.

Organization for Continuity

Section Chairman: If the work of the section is to go on from year to year smoothly and continuously and without a long hyatus immediately following the P.C.E.A. convention each year, it is highly desirable that the incoming chairman shall be a man who has been active in responsible work of the section during the previous year and who knows in advance that he is to have the responsibility of forming the new section im-

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* **Report of special reorganization subcommittee.**—Glen Smith, H. K. Griffin, J. F. Pollard.

[2] **Executive Committee.—H. K. Griffin,** Western States Gas & Electric Company, chairman. **W. C. McWhinney,** Southern California Edison Company, vice-chairman. **Clark Baker, Sr.,** National Lamp Works; **G. T. Bigelow,** The Southern Sierras Power Company; **J. O. Case,** General Electric Company; **H. H. Courtright,** Valley Electrical Supply Company; **H. M. Crawford,** Pacific Gas and Electric Company; **A. M. Frost,** San Joaquin Light & Power Corporation; **A. E. Holloway,** San Diego Consolidated Gas & Electric Company; **A. H. Nicoll,** Graybar Electric Company; **J. F. Pollard,** Coast Valleys Gas & Electric Company; **D. R. Ray,** Pacific Gas and Electric Company; **H. C. Rice,** Southern California Edison Company; **G. D. Smith,** Ontario Power Company; **G. C. Tenney,** Electrical West; **Morris Wales,** Coast Counties Gas & Electric Company; **J. W. Wrenn,** Great Western Power Company.

[3] **G. D. Smith,** Ontario Power Company, chairman. **W. P. Graef,** Southern California Edison Company, vice-chairman. **California Electrical Bureau:** G. M. Rankin. **Coast Valleys Gas & Electric Company:** J. F. Pollard. **Los Angeles Gas & Electric Corporation:** H. H. Randlett. **San Diego Consolidated Gas & Electric Company:** Alfred May. **San Joaquin Light & Power Corporation:** Lloyd Henley. **The Southern Sierras Power Company:** Albert Cage. **Western States Gas & Electric Company:** H. K. Griffin.

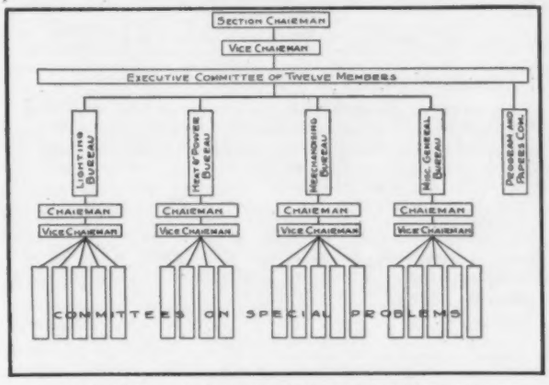
mediately after the annual convention. In general it is not desirable that the same section chairman be carried from from year to year, although in very rare and exceptional cases it might be found best to have the same section chairman serve two years in succession, although for obvious reasons it is recommended that new material be utilized in general for this office.

Section Vice-Chairman: Immediately after receiving his appointment from the incoming President of the P.C.E.A. the section chairman should in conference with the first vice-president of the P.C.E.A. select a vice-chairman for the section with the understanding and intent that this vice-chairman shall succeed to the section chairmanship one year later.

Section Executive Committee: The chairman with the aid of the vice-chairman, should then proceed to the selection of an executive committee of twelve members, in addition to themselves.

Bureau Chairmen: The executive committee under the leadership and direction of the chairman and vice-chairman, shall from their own number select the chairmen of the four bureaus into which the work of the section at this time naturally divides itself, viz: lighting, power and heating, merchandising and miscellaneous general, and other bureaus that might from time to time be authorized.

Bureau Vice-Chairmen: The chairmen of these bureaus in consultation with the vice-chairman of the section shall each select a vice-chairman for his bureau, preferably not from among the present executive committee personnel, with the understanding that these vice-chairmen will automatically be appointed the following year to the new executive committee and will become chairmen of their respective bureaus.



Organization chart of P.C.E.A. Commercial Section.

Committees: Committees under each bureau need not necessarily be the same from year to year but should vary in accordance with variations in the problems confronting the industry at the time.

The number and kind of committees to function during the year and the problems which they are to study or work upon should be determined at the first meeting of the new executive committee at which the chairmen and vice-chairmen of the bureaus should also be present.

All of this preliminary organization and planning can and should be done at the P.C.E.A. convention, when the personnel of the men who are to have the responsibility of carrying on, are known in advance. This meeting should be held at close of the last session of the Commercial Section at the convention, while the work of the previous year is freshly in mind and the problems upon which more light is needed are still apparent as a result of the general discussion and healthy disagreements that have arisen in the Section meetings during the convention.

Having determined the committees to be appointed the bureau chairmen with the approval of the section charman can then select the committee chairmen and personnel which should be completed and reported to the P.C.E.A. secretary within thirty days after the convention whereupon the work of the new year will be in full swing.

Conclaves: Inasmuch as one of the most valuable advantages to be gained from the work of the section is the personal discussion of problems and interchange of ideas and also for the purpose of setting up milestones during the year at which progress must be shown, it is desirable that three conclave meetings be held during the year at intervals of approximately three months, one to be held in northern California, one in southern California and one approximately midway between. Bureau and committee chairmen and vice-chairmen should attend all of these conclaves and unless they are in a position to do so they should not be appointed or accept appointment as such. It should be the duty and practice of the appointing officer to make this clear at the time of selecting and notifying his appointees that attendance on these interim meetings is essential.

In addition to the chairmen of the several groups all committeemen from northern California should at least attend one conclave in the North and southern committeemen should attend the southern conclave and everyone connected with the section should at least attend one big mid-year conclave at the central location.

Duties of Bureau Chairmen: Details of the work of the several committees shall be worked out under the sole direction and responsibility of the respective bureau chairmen.

Duties of Section Executive Committee: Budget allowances, matters of policy and the general plan of the year's work including dates and location of conclaves, shall be worked out by the executive committee of the section, under the guidance of the section chairman.

Papers and Program Committee: Papers and program to be presented at the convention shall be selected from those prepared by the several bureaus and shall be so selected and passed upon by a papers committee of five members of the executive committee, selected by its chairman who shall meet and make their selection at the last conclave meeting before the convention.

Lighting Committee Report[2]

Education in the Use of the Electric Light*

Talks to Luncheon Clubs

The committee talked to eighteen luncheon clubs in fourteen cities and towns in California to a total attendance of 1,350 business men.† The committee also offered this talk to member companies that they might carry the work into sections which could not be reached by the committee.

The committee furnished the demonstration equipment and rehearsed a speaker selected by the member company for its own organization.

Seven member companies availed themselves of this opportunity and to date have reported twenty-one talks in twenty-one towns to an approximate attendance of 1,100. This represents about one-third of the towns that will be reached by the member companies' speakers, which gives to date this summary:

	Clubs	Towns	Attendance
Committee	18	14	1,350
Member companies	21	21	1,100
Total	39	35	2,450

* **Report of lighting committee.—Clark Baker, Sr., chairman.** G. H. P. Dellman, vice-chairman.

[2] **Clark Baker, Sr.,** National Lamp Works, chairman. **G. H. P. Dellman,** San Diego Consolidated Gas & Electric Company, vice-chairman. **California Electrical Bureau:** V. W. Hartley. **Coast Counties Gas & Electric Company:** F. D. Beardsley, M. L. Foster. **Coast Valleys Gas & Electrical Company:** P. S. George. **Edison Lamp Works:** L. G. Gianini. **Electric Products Corporation:** T. W. Simpson. **General Electric Company:** A. M. Koch. **Great Western Power Company:** F. H. Woodward. **Illinois Electric Company:** D. C. Pence. **Pacific Gas and Electric Company:** C. D. Monteith, H. H. Robison. **San Joaquin Light & Power Corporation:** M. P. Lohse. **Southern California Edison Company:** C. M. Masson. **The Southern Sierras Power Company:** W. R. Chawner, **Western States Gas & Electric Company:** T. J. Janes. **Westinghouse Lamp Company:** R. S. Prussia. **Miscellaneous:** E. R. Butterfield.

† Detail of the talk with demonstrations will be found in the 1925-26 P.C.E.A. Proceedings.

In addition there is an unreported estimate by member companies of giving the talk before approximately 42 more clubs in 42 towns reaching approximately 2,200 more attendance.

The committee presents the following letters as an indication of the value of the work:

"In every instance it was extremely well received and while the results of such work are always intangible, I feel thoroughly satisfied that it has been of great value, both from the standpoint of the lighting phase of the electrical industry and the standpoint of the central station, which desires to stimulate business and public good will.

"I cannot compliment your committee too highly on this most excellent activity."

(Signed) JAMES F. POLLARD,
Vice President.
—Coast Valleys Gas & Electric Co.,
Salinas, Calif.

"I think this sort of thing is most valuable to the industry. My public has shown keen interest in better lighting. A member of the State Board of Health, a physician at Long Beach, said that every school and organization in California should be given an opportunity to hear this lecture.

"I have had several optometrists commend the industry for giving a subject of this kind to the public. In two or three cases our load has been increased by a change in the lighting system.

"It makes friends and improves public relations."

(Signed) WALTER G. BLOSSOM,
Field Superintendent of Education,
—Southern California Edison Company,
Los Angeles, Calif.

"As you know, the writer has delivered a number of lectures on lighting in accordance with your plan before luncheon clubs, etc., and being curious to ascertain the result of these lectures has inquired from various people attending, their opinion as to the value in general. The results are as follows:

In every case close attention was given to the lecture by those present and in not a single instance did anyone leave the hall previous to the completion of the lecture.

The value of the lectures was shown by many expressions of thanks for the information covered and assurances that they would look over their light installation, etc., for the purposes of improving them.

In the majority of instances, chairmen expressing their appreciation thanked the power company for its thoughtfulness in having a lecture of this type delivered to their members. The lecture being considered to be of great value to them in an educational light."

(Signed) J. W. WRENN,
Manager, Appliance Sales,
—Great Western Power Co., of Calif.

Jobbers' Meetings

The committee, through special meetings called for the purpose, talked to eleven electrical supply jobbing organizations in which they told the story of three years' work done by the lighting bureau of the association namely, lighting schools one year, luncheon club talks another year, and a combination of both following together with aims and ambitions which are to be recommended as future activities.

Aside from the eleven jobbers' own organizations a combined jobber representative meeting was held in Oakland and San Diego, where the same story was told. At the close of these talks a suggestion was offered by the committee that, in their opinion, one way to help convert this work into dollars and cents and kw-hr. was for each man present to carry as much of this message as he could remember to every electrical contractor customer he called upon. At each meeting an executive of the jobbing house instructed his men to take the necessary time when calling upon electrical contractors to tell them of the work of this bureau through the association, and at the same time gave an opinion of the splendid results that should and would be obtained if the contractor could be inspired to accept and maintain an interest.

At these 13 special meetings 510 jobber salesmen and executives were in attendance.

It was estimated that these 510 men could tell some part of this story to at least 2,000 electrical contractors. How far the message was carried, however, is unknown although many instances have come to notice which would indicate that considerable talking had been done among the electrical contractors by jobbers' men.

Sign Lighting

The committee felt the Proceedings of the association should be brought up to date on electrical advertising (sign lighting) and appointed a sub-committee to prepare a paper. Due to a change in company relation of the chairman of this committee which occurred at the most inopportune time, the paper will not be presented. The committee recommends the finishing of this paper for the consideration of the incoming lighting committee.

Street and Highway Lighting

A survey of installation and maintenance cost for highway lighting was made which is to be put in manual form for presentation to the California State Highway Commission as a guide.

Lighting Schools

A lighting school was conducted by the committee in San Diego Jan. 10-14, inclusive. The enrollment was as follows:

Electrical contractors	17
Jobber representatives	9
Central station representatives	2
Total	28

Attendance record 94 per cent.

An average of nine visitors per class was recorded.

Many letters were received by executives of the association commenting on the school. Following are excerpts of a few, typical of all:

"I wish to express my appreciation for the P.C.E.A. illumination course which I was fortunate enough to attend here in San Diego. I believe that education and specialization is the salvation for the electrical contractor and opportunities like this one are of inestimable value."

(Signed) ORLYN M. COLLINS,
Assistant Electrical Inspector,
Operating Department, City of San Diego.

"Many expressions of approval from the contractors and others in attendance indicate the value of the school to them and to the industry as a whole."

(Signed) R. P. WAKEMAN,
Representative, Illinois Electric Co., Los Angeles, Calif.

"Education of the men forming the first line of contact; that is the keynote which will go far towards correcting the problems which confront our industry.

"The lighting school conducted last week has started to fill a gap which was gradually widening. The constructive method, simple presentation and able manner with which the classes were conducted was reflected by the interest and enthusiasm of all present, not only during but after classes.

"Four of our road sales force were called in and instructed to attend all meetings. They were greatly benefited, and are now carrying the message to their trade. . . . Let's all get increased dividends on our investments by a continuation of educational work.

"No one would think of sending an army into the field with trained officers and untrained men. Yet that is the picture as we see it with the men on the firing line fighting hard against big odds, which can only be overcome by the better methods as shown in your school."

(Signed) FRED G. GOSS,
Asst. Sales Manager, Electrical Supplies, San Diego, Calif.

Banquet Entertainment

The lighting bureau asked and was granted permission to provide the entertainment for the annual P.C.E.A. banquet. The entertainment is to be of a spectacular nature—embracing the performance of light color vs. pigment color, instructively and entertainingly presented.

Merchandising Committee Reports[2]

General Merchandising*

California has set a national standard in its electrical development. The accompanying chart indicates what has been accomplished in building up domestic consumption. While these figures compare favorably with those of the entire country taken as a whole, the comparison is hardly a true picture. In this state there is a general average lower lighting rate, favorable to greater use, and a consumer list who live far above the average, as indicated by the number of automobiles in use, the amount of kw-hr. consumed in cooking and heating, and the general average improved living conditions. Therefore it should be expected that the annual kw-hr. domestic consumption should be considerably above that for the rest of the country.

included in this report, showing consumption figures higher than the average, has been following a consistent plan of merchandising home appliances for receptacle operation as well as conducting a year round range campaign. Several California companies, as a result of accomplishments attained by central stations in other sections, are already committed to periodic and intensive selling campaigns on receptacle appliances during 1927. The 1927 figures on domestic kw-hr. consumption, as compared with those shown herewith, will indicate what is being accomplished along this line. It is unfortunate that there are no reliable figures for 1925 with which to make a comparison of those shown.

One aggressive California company campaigned for the past two years on a popular priced device selling for $10, and has been successful in disposing

TABLE I—Comparative study of annual domestic Kw.-hr. consumption.

California Power Companies	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	Average of 10 Calif. Power Companies based on number of Consumers per Company	Average of all Power Companies in United States	Comparison of Calif. Companies with all Companies in United States
Average annual Kw.-hr. domestic consumption for light	261	333	351	297	252	324	438	293	403	408	341	339	100 per cent plus
Average annual Kw.-hr. domestic consumption for light, cooking and heating.	495	404	540	380	1,312	511	546	658	(a)	(a)	435	365	119 per cent plus
Average annual Kw.-hr. domestic consumption for light, cooking and heating consumers only	1,860	4,100	4,237	3,240	5,880	(b)	3,611	3,493	1,787	2,000	...	...	.....

(a)—Very light range load. (b)—No report.

Referring to the chart it is found that the figures shown for lighting load consumption only are practically on a par with those of the rest of the United States, whereas those figures showing consumption of lighting, cooking and heating are approximately 20 per cent above the national average.

The domestic load, including cooking and heating, has been developed by intensive and costly sales efforts and by the expense of heavier distribution systems, whereas the lighting load, which carries all appliances operated from the receptacle, is developed at no additional expense and at a comparatively lower selling cost. It is obvious, therefore, that if greater effort is devoted to the increase of this first classification, which will include better home lighting and the more general use of receptacle appliances including bath room heaters, electric ironing machines, and the general household utility line, a correspondinly higher increase of revenue will be derived and at a smaller cost.

It is not the province of this committee to outline or recommend selling campaigns to accomplish this purpose as each central station must adjust such plans to fit in with local conditions. One of the two campanies of over 9,000 to its consumers. A special check made on several hundred consumers of various types and in different parts of the territory who purchased this article, shows that the average increase per monthly bill was 80 cents, or an approximate yearly total of $86,000.

From all of the plans recommended by commercial managers who responded to the questionnaire sent out by this committee, the following were the more generally approved:

1. Support the Red Seal Plan.
2. Encourage sale of radio apparatus for operation from the lighting circuit.
3. Sell kitchen ventilation.
4. Promote the illumination of grounds for protection and ornamentation.
5. More effort on home devices.
6. Develop more refrigeration.
7. Encourage low follow-on type rate coupled with sales efforts on appliances and lighting for the home.
8. Collect data as included in this report and distribute to all, noting effect of rates and of sales policy.

An adoption of any or several of the suggestions made will not interfere with present established outlets of electrical merchandise. On the contrary, wherever we find a central station with an aggressive constructive selling plan we also find more prosperous and contented electrical contractor-dealers. In place of there being a division of business between the merchandising department of the central station and other merchandising outlets, more business is developed for everyone concerned.

* **Report of sub-committee.—H. C. Goldrick, chairman.** H. A. Cram, J. W. Ferry, F. E. Ford, M. L. Foster, J. W. Guilfoyl, Graham Holabird, C. J. James, J. H. Jamieson, A. W. Krueger, D. S. Manuel, Albert May, D. D. MacFarlane, Chas. Musladin, E. A. Norton, T. W. Ray, H. C. Rice, B. M. Tassie, R. E. Thompkins.

[2] **J. W. Wrenn,** Great Western Power Company, chairman. **E. F. Perkins,** Pacific Gas and Electric Company, vice-chairman. **Apex Electric Sales Company:** Arthur Kempston. **Alexander & Lavenson:** Chas. Musladin. **Barker Brothers, Inc.:** E. A. Norton. **Coast Counties Gas & Electric Company:** R. E. Farrand, M. L. Foster. **Coast Valleys Gas & Electric Company:** E. V. Wood. **Copeland Products, Inc.:** Geo. Campe, S. E. Pentz. **California Electrical Bureau:** V. W. Hartley. **Edison Electric Appliance Company:** H. A. Cram. **Electric Heating & Manufacturing Company:** O. W. Forsyth. **Electrical West:** G. C. Tenney. **Electric Vacuum Cleaner Company:** C. J. James. **Easy Housekeeping Shops:** F. E. Ford. **Electric Household Utilities Company:** J. W. Ferry. **Fobes Supply Company:** B. S. Manuel. **Frigidaire:** W. L. Cochran. **General Electric:** G. H. Ruck. **Graybar Electric Company:** H. C. Goldrick, Graham Holabird. **Great Western Power Company:** D. G. Taylor. **Kelvinator:** O. A. Brandel, L. D. Robertson. **Landers, Frary & Clark:** J. W. Guilfoyl. **Manning, Bowman Company:** B. M. Tassie. **Magnavox Company:** O. R. Doerr. **Newbery Electric Corporation:** E. D. MacFarlane. **Ontario Power Company:** F. L. Allen. **Pacific States Electric Company:** T. W. Ray, R. E. Thompkins. **Pacific Gas and Electric Company:** Gardner Buss. **San Diego Consolidated Gas & Electric Company:** Albert May, P. P. Pine. **San Joaquin Light & Power Corporation:** A. M. Frost. **Southern California Edison Company:** H. C. Rice, R. C. McFadden. **The Southern Sierras Power Company:** W. S. Fleming. **Truckee River Power Company:** O. S. Clifford. **Vallejo Electric Light & Power Company:** R. C. Bragg. **Westinghouse Electric & Manufacturing Company:** J. H. Jamieson. **Western States Gas & Electric Company:** G. A. Ferguson. **Miscellaneous:** W. W. Hicks, H. E. Mulvaney, Adolph Strauch, E. A. Wilcox.

Maintenance and Servicing of Domestic Ranges*

The Executive Committee of the Commercial Section assigned the following definite work for the Range Committee to accomplish this year:

(a) Secure data from the member companies showing their range servicing costs.

* **Report of sub-committee.—P. P. Pine, chairman.** F. L. Allen, R. C. Bragg, O. S. Clifford, R. E. Farrand, G. A. Ferguson, W. S. Fleming, A. M. Frost, R. C. McFadden, E. F. Perkins, R. C. Rice, D. G. Taylor, E. V. Wood.

(b) Make an investigation regarding the policies of the various utilities with reference to charges for such servicing.

(c) Work out a suggested plan by which the companies can keep account of this expense.

In order to secure data from the member companies a questionnaire form was prepared containing sixteen inquiries. Utilities having in excess of 90 per cent of the ranges connected to the lines of member companies of the association returned the questionnaire, giving as much information as was available.

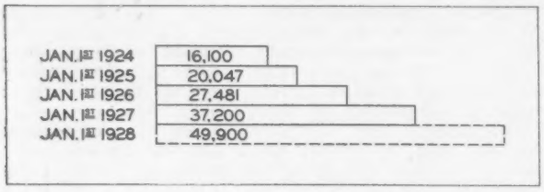


Fig. 1. Number of ranges connected to lines of member companies.

One of the salient features in connection with the range business is its increase "faster than the normal growth," The increase in the number of residential customers of association companies during 1926 was 7 per cent. The degree of public acceptance of the electric range is appreciated when it is realized that the reporting companies showed an increase in the number of ranges connected of over five times this figure or 35.5 per cent. That last year's growth was not abnormally large is shown by a recent survey of 1927 sales quotas which indicates an increase of over 30 per cent as compared with 1926. (See Fig. 1.)

Range Servicing Costs

The outstanding feature in connection with the companies which service their customers' ranges is the meager accounts kept of this expense. Probably most of the utilities feel certain that the business is profitable, after taking into consideration the large annual expenditure for servicing, and are willing to encourage the sale of ranges for this reason.

TABLE I—Range Questionnaire

Name of Company.....
Location .....

1. Number of residence customers..... .....
2. Number of ranges in operation Jan. 1, 1926.... .....
3. Number of ranges in operation Jan. 1, 1927.... .....
4. What is your policy as regards charging customers for servicing ranges sold by your company?
   (a) First year of service.....
   (b) Subsequent years .....
   (c) What is your policy as regards charging for servicing ranges not sold by your company?
5. How do you charge customer for servicing as regards
   (a) Labor .....
   (b) Transportation .....
   (c) Material (list or cost price).....
6. What was the company's total expenditure for range servicing during 1926?
   (a) Labor .....
   (b) Transportation .....
   (c) Material .....
7. Of this amount what was total amount charged customers for
   (a) Labor .....
   (b) Transportation .....
   (c) Material .....
8. What was total number of service calls made during 1926?
   .....
9. In case your company has a "free service" policy at what time in the life of the range do you decline such service free of charge .....
10. Does your company make any allowance to customers desiring to trade in a worn out electric range on a new one? If so how much?.....
11. Location of ranges.....Per cent rural?..... Per cent urban? .....
12. Do range servicing men do other work also?.....
13. Are you satisfied with your present servicing policy?.....
    .....
14. What suggestions would you make to range manufacturers which you think might reduce amount of servicing required?
    .....
15. Will you list in the order of their importance the nature of trouble causing your service calls? First..... Second ..... Third.....
16. Will you kindly send us copies of forms used in compiling range servicing records and explain your method of ascertaining servicing costs? .....
17. If your company has more complete records showing type and make of ranges, cause of trouble calls for the various types, the committee would be glad to receive them.

Of the fifteen reporting utilities representing over 90 per cent of the ranges connected to the lines of the member companies of the association, only two companies do not service ranges. It is a common practice (with one exception) for those companies which do maintain ranges to do so the first year after the sale without charge, the range manufacturers supplying the necessary parts. The same policy is usually followed irrespective of whether the utility or the dealer sells the appliance.

After the one year guarantee period has expired it is the common practice for the company to charge list price for the parts required. However, the labor and transportation expense, which generally amounts to more than the cost of the material used, are supplied free of charge.

That the range manufacturers have done much to perfect their product within the last three years is shown by the reduction in the number of service calls required to 1.55 per range per year. In 1923-24 it was common to expect an average of from two to two and one-half trips per range per annum to take care of necessary repairs. The manufacturers should receive the credit due them for making such marked improvements in their product. Had there been no beneficial changes made in bricks, terminals, switches and oven lining, which were the cause of heavy maintenance expense in the past, an increase in the number of service calls for the year 1926 would have been expected, due to the greater average age of ranges in use, with a correspondingly large amount of upkeep required. What the manufacturers can do to further reduce this expense will be considered later.

The average annual cost of maintenance per range was $3.79 per year, a reduction of over twenty per cent as compared with the figure of $5.00, which was regarded as the usual expenditure two and three years ago.

It is interesting to note the reduction in the number of service calls which a customer requests when he realizes that he is to bear part of the labor and transportation expense required to service the

Form [illegible]

SAN DIEGO CONSOLIDATED GAS AND ELECTRIC CO.

ELECTRIC-APPLIANCE RECORD

Date Connected	Name	Address

Appliance ..... Make ..... Model .....

New ..... Second-hand ..... Bought from .....

Remarks: .....

Order No.	Date	UNIT NUMBER		Charge	Remarks
		Replaced	Repaired		

Fig. 2. Electric appliance record.

range. Although the average number of calls per range per year was 1.55 this was reduced to .45 in the case of company "G" which made a practice of charging $1.50 per trip for responding to the trouble call.

The labor and transportation expense is relatively heavy for servicing in the range territory of our member companies on account of 53 per cent of the ranges being located in the rural districts.

Service Policies

A surprising result of the survey was that although 86 per cent of the reporting companies service their ranges and over half of the utilities do this work without charge to the customer, except for the materials used, these companies are satisfied with their present range policy.

Although the Range Committee of the Pacific Coast Electrical Association recently placed itself on record

TABLE II—Results from range questionnaire.

Company	Residence Customers	Number of Ranges			Charge First Year Service		Policy Dealer Range	Charge Customer			List or Cost	Company
		Jan. 1 1926	Average 1926	Jan. 1 1927	Labor	Material		Labor	Trans.	Material		
	1	2		3	4(a)	4(a)	4(c)	5(a)	5(b)	5(c)	5(c)	
A	354,433	8,746	10,549	12,353	No	Mfg.	Same*	No	No	Yes	List	A
B	292,400	6,987	8,202	9,417	No	Mfg.	Charge cost	No	No	Yes	List	B
C	40,657	3,312	3,660	4,008	No	Mfg.	Same	No	No	Yes	List	C
D	52,864	2,080	2,423	2,766	No	Mfg.	Same	No	No	Yes	Cost plus 25%	D
E					Do not service							E
F	13,027	1,212	1,442	1,672	No	Mfg.	Same	No	No	Yes	Cost plus 10%	F
G	32,224	856	1,036	1,215	No	Mfg.	Same†	$1.50 per trip		Yes	List	G
H	5,870	766	823	880	No	Mfg.	Same	No	No	No		H
I	6,310	687	699	711	Do not service							I
J	21,899	352	498	643	No	Mfg.	Customer Pays	No	No	Yes	List	J
K	8,000	310	430	550	No	Mfg.	Same	Cost plus 15%	Cost plus 15%	Yes	Cost plus 15%	K
L	12,397	212	346	481	No	Mfg.	Same	No	No	Yes	List	L
M	16,249	400	430	461	No	Mfg.	Same	No	No	Yes	List	M
N	5,614	114	115	116								N
O	870	15	25	36	No	Mfg.	Charge	Charge regular price		Yes	List	O
Totals	862,814	26,049	30,678	35,309	Gain 35.5%							

*Signifies same policy irrespective of whether utility or dealer sells range.
†On ranges sold by company.

TABLE III—Results from range questionnaire.

Company	Total Cost 1926				Charge Customer				Number Service Calls	Service Calls per range per year	Total Cost of Service per range per year	Company
	Labor	Trans.	Material	Total	Labor	Trans.	Material	Total				
	6(a)	6(b)	6(c)		7(a)	7(b)	7(c)		8			
A				37,100†			No data				3.52	A
B							No data					B
C	14,928*	2,988	9,526	27,442*			4,954*	4,954				C
D	5,200†		5,200	10,400	No	No	2,600†	2,600†	4,650	1.91	4.29	D
E					Do not service							E
F					No record							F
G	2,410	810	1,411	4,631	450†	Included with labor	952†	1,402	465	0.45	4.46	G
H	2,056	663	932	3,651					1,377	1.67	4.44	H
I					Do not service ranges							I
J							No record kept					J
K									150†			K
L	648	271	270	1,189	No	No	266	266	300†		3.45	L
M												M
N	130		161	291					336	2.90	2.53	N
O							No record		20	0.80		O
								Average		1.55	3.78	

†Estimated.
*Basis first six months 1926.

TABLE IV—Results of Range Questionnaire

Company	Allowance Trade in	Satisfied with Service policy	Service men do other work	How range manufacturer might reduce servicing	Nature of Trouble causing service calls			Company
	10	13	12	14	15			
A	No	Yes	Urban, No. Rural, Yes	Standardization of switches, coils	Coils	Automatic devices	Switches	A
B	No, working on plan now	Yes	Yes	Better switches, coils, automatic devices enamelling, factory inspection and crating	Coils	Switches	Enamel	B
C	Yes, 20 percent of new range	Not fully	Yes	Better elements, switches, packing	Coils	Switches	Packing	C
D	No	No	Yes	Standardization, better coils	Coils	Loose contacts	Automatic devices	D
E				Does not service ranges				E
F	No	Yes, want better records	Yes	Better crating	Coils	Switches	Automatic devices	F
G	No	Yes	Yes	Better factory inspection and crating	Coils	Switches	Bricks	G
H	Sell new one at cost	Yes	Yes	Have made progress lately by bringing heavier wires to elements and making top units and oven linings more accessible	Coils	Wires to elements	Switches	H
I				Do not service ranges				I
J	Yes	Yes	Yes		Coils	Switches	Thermostats	J
K	No	Yes	Yes		Coils	Automatic devices	Switches	K
L	No	Yes	Yes	Better crating	Coils	Switches	Automatic devices	L
M	No	Yes	Yes	Perfect automatic devices	Coils	Automatic devices	Switches	M
N	No	Yes	Yes		Coils	Bricks	Automatic devices	N
O	Yes, make small allowance and scrap range	Yes	Yes	Perfect elements	Coils	Switches	Connections	O

to the effect that the promotional stage, where it was necessary to sell ranges below list prices had passed, the utilities are evidently still almost unanimously of the opinion that it is necessary to cater to this business by supplying free labor and transportation for maintaining ranges.

There seems to be much room for honest difference of opinion as regards the amount of free servicing a utility should do. The current trade magazines have contained considerable discussion on this topic as applied to electric refrigerators.

It is interesting to note the experience of The California Oregon Power Company, which actively entered the range field in 1912. At that time, when the electric range was not so reliable a piece of electrical apparatus as it is today, the company sold ranges below list price and adopted a very liberal servicing policy.

Since then the company first raised the selling price of ranges and later, after the dealers became more active, it discontinued the sales, passing the burden of maintenance to the dealers at the same time. As early as 1923 the general agent of the company reported:

"We believe we have been reasonably successful in this procedure, inasmuch as 23 per cent of all our residential customers in this district have electric ranges installed, and we have eliminated a great deal of work and expense."

The furnishing of free service indefinitely may become burdensome, not only on account of the rapid growth in the number of ranges served, but also due to the increase of the average age of the ranges in use. That free servicing is not always essential is shown in the case of the Idaho Power Company which had 6,759 ranges connected to its lines Jan. 1, 1927, a saturation of 28 per cent. The policy of this company is to charge for labor, transportation and material after the guarantee period has expired at cost price plus 15 per cent.

TABLE V—Electric Range Maintenance, 1926

Number of ranges at beginning of year		856
Number of ranges at end of year		1,215
Average number of ranges for year		1,035
Total cost of repair:		
Material	$1,411.55	
Labor	2,410.00	
Transportation	810.00	
	$4,631.55	
Amount billed to customer	$1,402.39	
Net cost to company	$3,229.16	
Total cost of repair per range per year:		
Materials	$ 1.36	
Labor	2.32	
Transportation	.78	
	$ 4.46	
Net cost to customer per range per year	1.36	
Net cost to company per range per year	3.12	
Total trips made for repairs to ranges		465
Net cost to customer per trip	$ 3.02	
Net cost to company per trip	6.95	
Total cost per trip	$ 9.97	
Number of trips per range per year		449

The length of time during which ranges have been sold in a company's territory and the degree of acceptance of electric cooking should be one of the determining factors governing the policy of charging for servicing. As electric cooking becomes more general the time may come for a change from a liberal service policy to one where the customer bears this expense. Other factors to be considered are the competitive situation and the sentiments of the range customers. Of the many conditions which dictate as to who is to bear this burden, the attitude of the customer should certainly be considered before a change is made, if full consideration is given public relations. If the customers are willing to pay for this expense, the time has arrived for the utility to change its policy of liberal servicing.

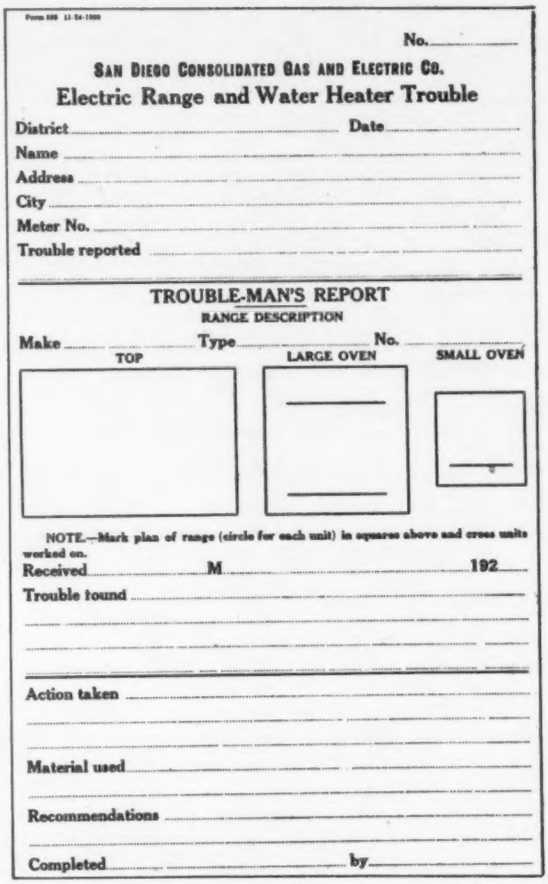
Causes of Service Complaints

It is noteworthy that without exception every reporting company testified that the coils were the most prolific cause of complaint. Switches, automatic devices, bricks, loose contacts, wires to elements and enamel, in the order named, were other sources of trouble and expense.

Inasmuch as all the utilities agreed that the coils were the most important cause of maintenance calls it is rather remarkable that comparatively few companies mentioned coils when asked for suggestions as to ways the range manufacturer might reduce the amount of servicing required.

Although the range manufacturers have made an advance during the last few years in reducing the causes of complaints, much further progress remains to be made. It would seem that it would be a comparatively simple matter for the manufacturers to follow the suggestion which received the highest number of "votes," namely: "Better factory inspection and crating."

The usual purchaser of an electric range has a comparatively high standard of living and is dissatisfied if an appliance which is purchased for new is delivered in a damaged condition. As a range is not only heavy, but is bulky as well, it is essential



No.

SAN DIEGO CONSOLIDATED GAS AND ELECTRIC CO.

Electric Range and Water Heater Trouble

District ..... Date .....

Name .....

Address .....

City .....

Meter No. .....

Trouble reported .....

TROUBLE-MAN'S REPORT

RANGE DESCRIPTION

Make ..... Type ..... No. .....

TOP LARGE OVEN SMALL OVEN

NOTE.—Mark plan of range (circle for each unit) in squares above and cross units worked on.

Received ..... M ..... 192....

Trouble found .....

Action taken .....

Material used .....

Recommendations .....

Completed ..... by .....

Fig. 3. Range and water-heater complaint report.

that it be prepared properly for shipment if it is to be delivered with the enamel in perfect condition and the paint unscratched, to say nothing of more serious possible injuries. The party who installs the range can co-operate in reducing service calls by making certain that all adjustments are properly made, contacts and connections sufficiently tight and the frame and mechanical parts correctly assembled and in working order, before the range is left in the hands of the customer.

Standardization of range parts, perfecting of automatic devices, and improvement of switches, coils and enamel were other suggestions made by which the manufacturer might improve his product. Particular attention might well be given to using of few types and sizes of parts which need frequent replacing, inasmuch as this will reduce the required stock of parts necessary to be carried and greatly facilitate servicing. Competitive manufacturers might co-operate in this with consequent advantage to all concerned.

TABLE VI—Electric range sales and repairs, 1926, San Diego Consolidated Gas & Electric Company.

Model	On Lines at End of 1925	Added During Year	On Lines at End of 1926	Repairs Average	Repairs Trips	Repairs Parts	Cost of Repairs	Charged to Consumer	Net Cost to Company	Cost per Range per Year to Consumer	Cost per Range per Year to Company	Trips per Range per Year
A-1	200	16	216	208	78	136	——	$ 431.22	——	$2.07	——	0.375
A-2	32	6	38	35	22	34	——	100.20	——	2.86	——	0.630
A-3	115	59	174	144	108	94	——	103.00	——	0.72	——	0.750
A-4	0	4	4	2	0	0	——	0.00	——	0.00	——	0.000
A-5	62	9	71	66	14	18	——	33.00	——	0.50	——	0.210
A-6	0	7	7	4	5	1	——	6.35	——	1.59	——	1.250
Total A	409	101	510	459	227	283	——	673.77	——	1.47	——	0.495
B-1	41	5	46	44	25	33	——	65.00	——	1.48	——	0.570
B-2	30	8	38	34	27	54	——	126.95	——	3.73	——	0.790
B-3	25	79	104	64	41	31	——	0.00	——	0.00	——	0.640
B-4	0	43	43	22	1	0	——	0.00	——	0.00	——	0.045
B-5	170	43	213	191	77	140	——	253.12	——	1.32	——	0.400
B-6	3	18	21	12	9	9	——	4.00	——	0.33	——	0.750
B-7	6	4	10	8	3	9	——	0.00	——	0.00	——	0.375
B-8	3	1	4	4	6	3	——	3.25	——	0.81	——	1.500
B-9	1	0	1	1	0	0	——	0.00	——	0.00	——	0.000
B-10	6	13	19	12	0	0	——	0.00	——	0.00	——	0.000
C-1	16	0	16	16	0	0	——	0.00	——	0.00	——	0.000
C-2	15	0	15	15	40	45	——	240.55	——	4.45	——	2.650
C-3	6	0	6	6	0	0	——	0.00	——	0.00	——	0.000
D-1	16	1	17	17	0	0	——	0.00	——	0.00	——	0.000
Total B-C-D	338	215	553	446	229	324	——	692.87	——	1.55	——	0.513
Others	109	43	152	130	9	16	——	35.75	——	0.27	——	0.069
Total	856	359	1,215	1,035	465	623	$6,131.55	$1,402.39	$4,729.16	$1.36	$4.56	0.450

Form H 3-26-250

A

MAINTENANCE
ELECTRIC RANGES AND WATERHEATERS

MONTH 1925 192

NAME	Number of Orders	CALLS Company X	CALLS Company Y	CALLS Others	Date of Order	Order Number	RANGES Make	RANGES Trouble Reported	RANGES Fuse	RANGES Wiring	RANGES Unit Switch	RANGES Time Switch	RANGES Thermostat	RANGES Terminals	RANGES Unit	RANGES Oven Lining	WATER HEATERS Switch	WATER HEATERS Wiring	WATER HEATERS Element	Time (in hrs)	Miles	Date Completed	Workman
January	48	17	25	6					3	8	13	5			14		1			109			
February	53	23	18	12					2	10	7	4	4	6	19	1				113½			
March	30	11	15	4					2	1	6	2	3	1	10	1				70			
April	52	20	22	10					5	4	10	1	4	4	12	6	4			2120½			
May	47	28	17	2					6	8	5		4	3	15		1			98½			
June	38	12	19	7					7	3	4	1	4	6	17					71			
July	42	19	16	7					7	6	8	1	3	3	7	1		1		67½			
August	35	10	16	9					2	3	7	1	2		15	1				65½			
September	28	12	10	6					1	2	5	1	4		14	1	1	1		60			
October	48	18	16	14					2	5	12	2	2	1	19	3			2	91½			
November	38	11	14	13					1	7	3	2	2	2	8			1	2	79½			
December	34	10	14	10					1	1	9	2	4	1	9	1	1	1	1	55½			
Total	493	191	202	100					39	58	89	22	36	27	159	15	10	4	7	1002½			

B

MAINTENANCE
ELECTRIC RANGES AND WATERHEATERS

MONTH 1926 192

NAME	CALLS Company X	CALLS Company Y	CALLS Others	CALLS Total	Date of Order	Order Number	RANGES Make	RANGES Trouble Reported	RANGES Fuse	RANGES Wiring	RANGES Unit Switch	RANGES Time Switch	RANGES Thermostat	RANGES Terminals	RANGES Unit	RANGES Oven Lining	WATER HEATERS Switch	WATER HEATERS Wiring	WATER HEATERS Element	Time (in hrs)	Miles	Date Completed	Workman
January	17	14	11	42						7	2	1	4		22	1	2			62½			
February	13	10	13	36						4	5		3		15		2			53½			
March	13	10	6	29						3	2		3	1	12	1	2			44			
April	10	15	7	32						5	6		3		9				1	40			
May	13	18	8	39					2	3	5		5		15		1			46			
June	24	19	10	53					3	10	4		5	1	18	1	2		2	78			
July	11	13	4	28					2	7	4	3	1		11	1				32			
August	9	7	3	19					1	4	1	1	2		6					24½			
September	6	11	5	22						4	3		2		10		3			37 (Approx.)			
October	10	15	8	33					2	1	8	1	1		17	1		1		51			
November	12	13	9	34					2	1	4	1	1		13					41			
December	13	15	6	34					2	7	3		2	1	14	1		2	1	50½			
Total	151	160	90	401					15	56	47	7	32		3162	6	12	3	4	560			

Fig. 4. Range maintenance forms and records (A) 1925, (B) 1926.

TABLE VII—Electric range repairs, 1926, San Diego Consolidated Gas & Electric Company.

	Trips	Coils	Switches	Bricks	Thermostats	Thermometer	Oven Units	Units	Fuses	Knobs	Plugs	Terminals	Timers	Hinge Support	Appliance Plug	Rebuild	Contact	Oven Top	Cooking Top	Door Catch	Wire	Door Lining	Heater Assembly	Oven Lining	Adapter	B. Pan and Rack	Miscellaneous	Parts
B-1	25	9	15	2	0	2	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	33
B-2	27	29	12	6	0	0	1	0	1	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	54
B-3	41	13	3	4	0	0	0	1	2	0	0	0	2	0	1	0	4	1	0	0	0	0	0	0	0	0	0	31
B-4	6	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
B-5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B-6	77	66	51	13	1	0	0	0	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140
B-7	9	2	3	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
B-8	3	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
B-9	40	8	4	2	0	0	1	3	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	23	0	1	45
Total B	229	131	92	29	2	5	5	4	6	5	6	0	2	1	2	0	7	1	0	1	0	0	0	0	23	0	2	324
A-1	14	16	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
A-2	98	41	3	5	11	5	0	7	1	0	0	0	0	0	0	0	0	0	6	1	1	1	1	0	0	0	1	84
A-3	10	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	0	0	10
A-4	78	43	16	14	3	1	6	7	3	1	3	20	0	0	0	1	1	0	0	0	5	0	1	2	0	2	7	136
A-5	22	12	3	9	3	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	34
A-6	5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total A	227	117	22	30	18	6	6	16	4	1	3	23	0	0	0	1	1	0	6	2	8	3	3	2	0	2	9	283
Others	9	10	4	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Range Total	465	258	118	59	20	11	11	22	10	6	9	23	2	1	2	1	8	1	6	3	8	3	3	2	23	2	11	623

Plan for Keeping Account of Service Expense

From the meager data on servicing costs which the reporting companies had available it is evident that most of the utilities do not consider that the knowledge of these costs is worth the expense of keeping detailed records.

The trend in busines today seems to be to go to greater lengths to accurately determine expenditures. The range servicing costs have been such a relatively small part of the operating expense of the utility, however, that this detail has received scant consideration in most instances.

There are some definite advantages, however, which the service company will secure by knowing more details regarding these expenditures. It is noteworthy that one of the reporting companies which is keeping a close record of its servicing expense is one of the few which charges its customers for the labor and transportation of service calls after the guarantee period has expired. It is logical to expect that the first step in reducing an expense is to make an analysis of the expenditure incurred.

Even after a system of accounting is set up it is not necessary for the company to continue making detailed reports. When it is desired to compare the efficiency of service men or to determine the relative maintenance expense of various types or makes of ranges records can be analyzed until the desired information is obtained without continuing to spend money for data which is of little use.

The electric appliance record (Fig. 2) shows at a glance the entire history of the large heating appliance. This is made out at the time the sale is made or, in the case of the appliance being sold by a dealer, when the range is connected. These are filed alphabetically in the customer's name.

When a service complaint is made the form shown in Fig 3 is used, being made out in duplicate. As much information is obtained from the customer as he is readily able to give. If there is any question as to the make or type of range, the appliance record (Fig. 2) is referred to and the data entered on the order before the original is turned over to the troubleman. The order clerk files the duplicate until the completed original is returned, when he enters the result of the call on the record form and files the original order according to number. If the customer is to be billed, the amount is entered on the duplicate, which is forwarded to the billing clerk. Otherwise, the copy is destroyed.

Detailed information regarding servicing cost is readily obtained at any time by gathering data from the record sheets (Table V). Although the amount billed the customer is not segregated, this information was available had it been desired.

In case the utility wishes to check the servicing of a certain troubleman, or a given district, this is readily done by listing the results of the trouble orders on the form shown in Fig. 4. The summaries listed on these forms for the years 1925 and 1926 show an increased efficiency of the serviceman handling this district. Two and three one-hundreds hours were required per call in 1925 as compared with 1.4 hours the following year.

When an analysis is made such as shown on Tables VI and VII showing in detail the parts of the various ranges which need servicing, some interesting comparisons are revealed. Such data readily shows the sources of weakness in any given type or make of range. Needless to say, such information is invaluable in assisting sales executives to determine what range is most profitable, from a service viewpoint, to place on the lines.

Conclusion

The future of the electric range was never brighter. Customer acceptance is increasing. Manufacturers are improving their product, increasing production and have reduced their prices. Since the exhaustive range survey by the National Electric Light Association the utility executives are more convinced than ever that the load is a profitable one. Most companies are satisfied with their servicing policy. If conditions warrant it, a change is readily made. In case such information is needed a simple accounting system to determine maintenance expense is easily set up.

With an increasing number of customers accepting electric cooking, with manufacturers able to produce more ranges than ever before, and with the utilities having an abundance of power to serve this rapidly growing load, we can look forward to the coming year with confidence.

Electrical Refrigeration*

Marked increase in public interest in domestic electric refrigeration seems to bear out the statement that within the next five years the number of units sold will approach the annual production of the automobile industry. With public interest at a high pitch, it behooves the electrical industry to make the most of the present opportunity by giving the public full and complete information upon the advantages of electric refrigeration.

With this idea in mind, the Refrigeration Committee has prepared an elementary manual on refrigeration, in which the answers to the ordinary questions asked by one interested in the subject are set forth. This manual is not designed for the salesman. It was prepared for those members of the industry in close touch with the public who might be questioned on the merits, advantages and cost of electric refrigeration. It has been compiled for use by the meter reader, collector, wireman, counter clerk and even by executives themselves.

It is the plan of the committee to print as many copies of the manual as its appropriation will permit, to be distributed free to member companies. Additional copies will then be supplied at a nominal

* **Report of sub-committee.—Gardner Buss, chairman.** O. A. Brandel, Geo. Campe, W. L. Cochran, R. L. Eltringham, V. W. Hartley, E. A. Norton, S. E. Pentz, W. J. Reynolds, L. D. Robertson, G. J. Ruck, G. C. Tenney.

charge. It is the suggestion of the committe that copies of the manual be placed in the hands of every power company employee who contacts with the public, as well as the employees of jobbers and contractor-dealers. It is further suggested that a letter from an executive of the company accompany each manual so distributed. As a check upon whether the employee reads the manual, the committee proposes the plan of enclosing in each copy distributed one or more prospect cards of the type used by the various companies. The return of these cards to the district manager or head of the sales department will indicate the extent to which the manual has been read.

In order to attract the interest of the employee in the manual, it is planned to use the accompanying illustration on the cover. The full text of the manual follows:

If She Asks You Tell Her

An explanation of a few of the simple principles of electric refrigeration, together with answers to those questions that might be asked of any member of the electrical industry by an interested housewife.

Prepared by the
Refrigeration Committee, Commercial Section
Pacific Coast Electrical Association, 1927.

"THE thingamajig pumps the what-you-call-it into the whats-its-name where it does something that makes it cold and you have ice."

An electrical man was trying to explain the working of an electric refrigerator to a friend. He continued:

"No, I haven't one. They cost too much. The stuff they use in them smells and they make a lot of noise, but a lot of people are buying them."

His friend was a prospect for an electric refrigerator. But not any longer. Here was a man in the electrical business who said they were not much good. His friend would wait a while. If the friend ever was approached by a refrigerator salesman he would repeat what the electrical "expert" told him, and show the salesman that he knew a thing or two about refrigeration.

What that electrical man did not know was that electrical refrigeration is economical, is feasible and is essential in the home. He did not realize that he was spoiling the sale of a device that is highly desirable from the standpoint of the customer and the power company. Nor did he realize that he was showing himself to be ignorant of electricity's newest contribution to the comfort and convenience of the home.

The next time a friend asks you about electric refrigeration, you can answer intelligently if you will read and remember the following questions and answers:

Q. Is the electric refrigerator practical?

A: Yes, the period of experimentation is over, and the electric refrigerator today is as practical as the vacuum cleaner and the washing machine.

Q: What advantage has the electric over the ice-cooled refrigerator?

A: Maintenance of even temperature. The ice-cooled box is at its coldest only when the ice compartment is full of ice; even then it is only about 50 deg. F. As the ice melts, the temperature rises. The electric refrigerator holds a much lower temperature which is automatically controlled and constantly maintained. It provides freedom from ice deliveries, yet a constant supply is on hand for cool drinks, etc.

Q: How much do they cost?

A: There are large ones and small ones. I see them in three-room apartments and in the largest homes. They use them in stores and hotels, too. There is a refrigerator for sale at a price to meet the requirements of anyone.

Q: How do they work?

A: They work just like the big cold storage warehouses. In fact they are really a small cold storage warehouse for your home.

Q: What makes the food compartment cold?

A: Everything we know of has some heat in it. What we call cold is really the absence of heat, just as darkness is the absence of light. All you have to do to make a refrigerator cold is to take some of the heat out of it. In an ordinary refrigerator, ice is used to take the heat out. In an electric refrigerator the frost coil takes the place of ice. It is colder than ice, and it keeps cold all the time.

Q: How do they make the ice cubes?

A: They have a coil in them that is 12 or 15 degs. colder than ice, so when you put water in the trays it freezes. You can make ice from water of your own selection.

Q: Why are they colder than an ice box?

A: Ice is only cold because it melts, and ice melts at 32 deg. The coil in an electric refrigerator is 12 to 15 deg. colder than ice, so the food compartment is colder too.

Q. The advertisements say they produce a dry cold. Why is that?

A: There is always a certain amount of moisture in the air, both in the room and in the refrgierator, and in the old style refrigerator the melting ice causes still more dampness. The frost coil in an electric refrigerator is so cold that the moisture that is in the air circulating through the food compartment freezes on the coil. That is also the reason why odors do not travel from one food to another in an electric refrigerator. The odors are carried by the moisture in the circulating air, and in an electric refrigerator the moisture and the odors too are left on the coil.

Q: What makes the air circulate?

A: Warm air always rises and cold air drops, so when the air passes over the frost coil it drops and forces the warm air ahead of it, so that there is a constant circulation.

Q: How much do they cost to run?

A: They have a small motor in them and it doesn't run much of the time. I am sure they cost less than ice.

Q: Are they reliable?

A: Most electric refrigerators are made by reliable firms. It is about like the car you buy. If you get one that is made by a reliable manufacturer you are almost sure to get a good one, and if some little thing should go wrong you know where you can get service.

Q: Are they much trouble to look after?

A: They are no trouble at all. They work automatically and all you will have to do is to oil the motor about every six months, the same as you do on a sewing machine or a vacuum cleaner, and occa-

sionally the electricity is turned off for a day to allow the frost which gathers on the coils to melt.

Q: Are they perfectly safe?

A: They are quite safe. There are so many of them in use now, many of them in hospitals and institutions, and I am sure the government would not use them if they were at all dangerous.

Q: How long have they been made?

A: The large refrigerating plants have been made for more than fifty years. The household electric refrigerator has been made for about twelve years now.

Q: How long do they last?

A: They have not been in use long enough for any of them to wear out yet.

Back in the factories where they are made the manufacturers make what they call life tests. The first machines that were made have been running night and day since they were made, and that is equal to more than twenty-five years' use in a home.

Q: How do you know when to turn off the electricity?

A: The machine itself turns the electricity on as it needs it and turns it off when it is not needed any more. You will not have to worry about that at all.

Q: We go away for a month every summer. Would it be much trouble to disconnect it then?

A: All you will need to do is to turn off the electricity at the refrigerator when you go away and turn it on again when you get back.

Q: Can I make ice cream in it?

A: No. Not the ordinary commercial kind. Ice cream must be agitated while being frozen, but many delicious frozen desserts can be made with electric refrigeration, such as frozen fruit salads, sherbets, mousses, parfaits, etc. The manufacturers supply complete instructions for the preparation of these desserts.

Q: Could I save any money by turning it off every night?

A: The biggest advantage of electric refrigeration is the fact that it maintains a constantly cold temperature. The machine only uses current as it is needed, so you would not save anything by turning it off at night.

Q: How much longer will food keep in an electric refrigerator than in an ordinary ice box?

A: Due to the lower temperature and drier atmosphere maintained by electric refrigeration, foods may be kept safely for much longer periods. Take milk, for example. It is not at all unusual for users of mechanical refrigeration to use milk that is three or four days old, thinking it was the last that was delivered. Fresh meats can be kept for a number of days, which is a real economy in running the household. A great deal of food that would ordinarily be thrown away and wasted is preserved and used by owners of electric refrigeration. The amount of food that is saved in this way will go a long way toward paying for the equipment in the course of the year.

Q: Do I need any special wiring?

A: No. The motor on an electric refrigerator requires about one-third the current that an electric iron consumes. The machine can be connected to a base plug.

Q: Are they noisy?

A. The modern electric refrigerators have the moving parts mounted in a cradle of springs. They are very quiet in operation.

Q: How often do I need to clean the drain?

A: The cleaning of the drain is a problem that users of electric refrigeration do not have to contend with. It is only about twice a month that any water will run down the drain at all, and then it will only be the small amount which had accumulated on the coil in the form of frost. The dirt that is cleaned from the drain pipe of an ordinary ice box is chiefly made up of foreign matter that is present in the ice compartment.

Q: Can I put the equipment in my present ice box?

A: If the refrigerator is in good condition and is well insulated, it may pay you to make an installation in it. Most of the manufacturers supply equipment to be installed in existing ice boxes.

Q: What do you mean by insulation?

A: Insulation is merely a heat resisting substance which is put in the walls of a refrigerator to prevent the heat of the room from getting into the food compartment. Formerly many materials were used for this purpose and many of the ordinary commercial refrigerators are very poorly insulated. Makers of electrically refrigerated cabinets almost all use pure cork board, because cork is the best known and most efficient insulator.

A Manual of Electric Air Heating*

This manual of Electric Air Heating is intended to present, succinctly and accurately, definite information relative to electric air heating. The data presented have been obtained from several years of practical experience and from many installations. It is, therefore fair to state that the information herein contained is accurate and that from this information may be obtained a general cross-section view of conditions.

This manual shows

1. The advantages to the user of electric heat.
2. A method of estimating the sizes of heaters required for various installations.
3. A method of calculating energy consumption.
4. Some actual data on energy used in existing installations.
5. Tables of heat losses by conduction through various materials.
6. Tables of temperatures.

No attention is paid in this manual to sales methods, plans or programs.

General

The use of electricity for the heating of air is becoming more extensive. A check of the sales by electric heater manufacturers clearly reveals this fact. Sales are of marked volume and are reported as increasing rapidly. This is true because of the increasing familiarity on the part of the public, the convenience, safety and ease of control afforded, and the growing importance of this service as a load-builder for central stations. Many power companies are actively soliciting this type of load because of its earning power. Salesmanship is not alone responsible for this load development. The merit of this type of heating is evidenced by the rapidly increasing number of satisfactory installations, each of which contributes to the further advance of the business.

The advantages in the use of electricity for air or space heating, as it affects the consumer, central station, manufacturer or merchandiser of equipment, are worthy of consideration. To have reached even its present state of development this service must have been of real benefit to the consumer and of profit to the power company, as well as to the selling agencies.

Too much information is already available on this subject to go into intimate detail in this manual. It is general knowledge that there are many hundreds of satisfied users of this form of electric service and that many power companies regard the load as very attractive. Many companies have indicated their intention more actively to solicit this type of load and the growing number of installations refutes any thought that electric air heating is not acceptable to the public.

Manufacturers and merchandisers of electric air heating equipment may find it necessary to redirect their channels of distribution. They will, too, undoubtedly be compelled to give more thought and attention to intelligent publicity.

Local conditions, such as climate, prevailing temperatures, generating and distribution costs (reflected in rates) type of building construction, habits of users and other factors exert a material influence upon the growth of the business. The colder winter climates of the Middle West and Eastern states offer somewhat more of a problem in the use of electric heat as a primary system than the milder climates of the

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* **Report of sub-committee.—E. A. Wilcox, chairman.** G. W. Barker, R. C. Bragg, O. R. Doerr, O. W. Forsythe, W. D. Hicks, Arthur Kempston, H. E. Mulvaney, Adolph Strauch.

The work of the 1927 committee was expedited greatly by, and grateful acknowledgment hereby is made to, the personnel of the 1926 sub-committee of the electric cooking and heating committee, Commercial Section, P.C.E.A.: R. C. Bragg, chairman; J. W. Wrenn, secretary; W. Wesley Hicks, E. A. Wilcox, H. V. Mooney.

Southern and Pacific Coast states but this problem is common to all heating systems. Sections enjoying low steam or hydro generating costs and low distribution costs are in a better position to benefit from electric heating than those less advantageously situated. It is, therefore, not remarkable that electric air heating had its practical inception on the Pacific Coast and that its growth in that area has been phenomenal. However, it has been demonstrated that electric air heating is practical in nearly every section of the country.

Regardless of its geographic location, any well constructed building can be heated to comfort with electricity. Decision as to the use of electric heat must be based on a comparison of its relative advantages and cost with the disadvantages and cost of fuel. In every community there are electric service customers who are able and willing to use electric heat even at a cost higher than that of even the cheapest fuel systems.

Advantages

The major advantages of electric heat are:

1.—Healthfulness.—The air is not vitiated nor destroyed, either by the generation and discharge of noxious fumes or by the combustion of oxygen. There is no moisture of combustion—because there is no combustion.

2. Cleanliness.—No smoke, soot, grease, dirt, moisture or disagreeable odors are given off.

3.—Convenience.—No fuel or ashes have to be stored or handled. No fires have to be lighted, watched or otherwise tended. Furniture, fixtures and draperies are not harmed. Refinishing of walls is not occasioned. Temperatures may be controlled either manually or automatically. Heaters may be moved from place to place or may be permanently mounted where they will tender the best service. Heat is available instantly without delay.

4. Safety.—When electric heaters have been so designed and constructed as to meet the requirements of the Underwriters' Laboratories of the National Board of Fire Underwriters, and have been properly installed, they represent the safest type of heating equipment that can be obtained .

5. Economy.—In properly designed heaters all of the energy consumed is applied to useful work. No other heating equipment works at such high operating efficiency. Chimneys and flues are unnecessary, as are coal bins and ash pits or oil tanks. Construction expense is thereby reduced, space is saved, investment lowered and carrying charges materially lessened.

Complete Electric Homes

Due to the cost and difficulty of obtaining competent servants, many families in modest circumstances make their homes of from five to eight rooms completely electric, including lighting, cooking, water-heating, air-heating and appliances. In such cases the housewife can readily do the daily tasks herself without great exertion. The total yearly cost for such electrically equipped homes averages from $175 to $325 per year where the temperature does not go below 20 deg. F. and electricity is available at an average rate not exceeding 2½c per kw-hr. Such conditions now are obtainable in large areas. This amount is well within the range of a large class of people, when the saving in other ways is taken into consideration.

Complete Electric Apartment Houses

Apartment house owners have come to realize the advantage of electric heating, which eliminates the services of a janitor and the necessity of operating continually a central heating system for the convenience of a few tenants who might require almost constant heat. Electric heat is available to each tenant at any hour that it may be required. Energy for these apartments is usually purchased on a master meter and resold to the tenant on a sub-meter. In this way a low average rate is earned. Some apartment house owners sell for a lower rate than that which they pay but are justified in doing so inasmuch as all attendant and repair charges are eliminated.

Hotels

A number of hotels have been equipped electrically with the result that they are giving entire satisfaction where a sufficient capacity of the proper kind of heaters has been installed to take care of the radiation losses of the building. It is usual in making an installation in a hotel to install the distribution panel controlling each heater in the office so that the clerk in charge can turn on the heater as soon as the room has been let. The heater is then operating by the time the occupant arrives in the room. The switch can also be pulled when the key is returned to the desk if so desired.

TABLE I—Watt-hr. loss per sq. ft. of surface for various temperature differences expressed in degrees F.

Nature of Surface	10 Deg.	20 Deg.	30 Deg.	40 Deg.	50 Deg.	60 Deg.	70 Deg.
Single glass	3.0	6.0	9.0	12.0	15.0	18.0	21.0
Double glass	1.7	3.4	5.1	6.8	8.5	10.2	11.9
Single skylight	3.5	7.0	10.5	14.0	17.5	21.0	24.5
Double skylight	1.8	3.6	5.4	7.2	9.0	10.8	12.6
8-in. brick wall	1.3	2.6	3.9	5.2	6.5	7.8	9.1
8-in. brick furred and plastered wall	0.7	1.4	2.0	2.7	3.4	4.4	4.7
12-in. brick furred and plastered wall	0.6	1.2	1.8	2.4	2.9	3.5	4.1
24-in. brick wall	0.6	1.2	1.8	2.4	3.0	3.6	4.2
8-in. concrete wall	1.6	3.2	4.8	6.4	8.0	9.6	11.2
8-in. concrete furred and plastered wall	0.8	1.6	2.5	3.3	4.1	4.9	5.8
12-in. concrete furred and plastered wall	0.7	1.5	2.2	2.9	3.7	4.4	5.1
24-in. concrete wall	0.7	1.4	2.1	2.8	3.5	4.2	4.9
4-in. hollow tile, plaster both sides	1.5	3.0	4.5	6.0	7.5	9.0	10.5
8-in. hollow tile, plaster both sides	1.2	2.4	3.6	4.8	6.0	7.2	8.4
4-in. tile, stucco and plaster wall	1.0	2.0	3.0	4.0	5.0	6.0	7.0
8-in. tile stucco and plaster wall	0.8	1.6	2.4	3.2	4.0	4.8	5.6
Corrugated iron	3.3	6.6	9.9	13.2	16.6	19.9	23.2
Wire lath and plaster	1.9	3.8	5.6	7.5	9.4	11.3	13.1
Frame wall with clapboard only	1.3	2.6	3.9	5.2	6.5	7.7	9.0
Frame wall with sheathing and paper	0.8	1.6	2.5	3.3	4.1	4.9	5.8
Frame wall with sheathing and asbestos	0.7	1.4	2.0	2.7	3.4	4.1	4.7
Frame wall, plaster outside	1.3	2.6	3.9	5.2	6.5	7.8	9.1
Frame wall, double board outside	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Partition, lath and plaster both sides	1.2	2.4	3.6	4.8	6.0	7.2	8.4
Partition, lath and plaster one side	2.0	4.0	6.0	8.0	10.0	12.0	14.0
Partition, 1-in. wood	1.8	3.6	5.4	7.2	9.0	10.8	12.6
Partition, 2-in. wood	1.2	2.4	3.6	4.8	6.0	7.2	8.4
Wooden floor, double board	0.3	0.5	0.8	1.0	1.3	1.5	1.8
Concrete floor	0.9	1.8	2.7	3.6	4.5	5.4	6.3
Wooden floor on concrete	0.4	0.8	1.2	1.6	2.0	2.4	2.8
Dirt floor	0.6	1.2	1.8	2.4	3.0	3.6	4.2
Plaster ceiling, no floor above	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Plaster ceiling, floor above	0.8	1.5	2.3	3.0	3.8	4.5	5.3
Wooden ceiling, composition roof	0.9	1.8	2.7	3.6	4.5	5.4	6.3
Watts per cu. ft. of air required to heat air	= .0054 per degree of temperature difference.						

Note—The accuracy of these tables can not be guaranteed for the reason that no two authorities seem to agree exactly. However, these figures have been used for some time with very satisfactory results, and they are certainly sufficiently correct for ordinary practical purposes.

Schools

Safety and automatic temperature control are very important factors in school heating. Schools are heated but a few hours per day and five days per week, with many holidays and vacation periods, resulting in low operating costs, when electric heat is used, as janitors are not required for the operation of electric heating systems. Oftentimes members of the staff wish to spend extra time after school hours and holidays. In these cases they can heat the individual room which they are occupying without the necessity of operating the entire plant. The initial cost of electric heating systems in this type of building is usually much lower than that of other heating systems. This is an added feature as money for school buildings is not readily available. In

TABLE II—Typical operating costs of electric heating.

Residences

Lighting and Heating only

	San Francisco Load, 9.8 kw.	San Francisco Load, 13.2 kw.	San Francisco Load, 11.9 kw.	San Francisco Load, 14.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	932	970	2,410	988
February	795	1,238	1,021	427
March	409	974	603	158
April	381	472	408	215
May	260	332	377	158
June	160	426	316	89
July	187	139	260	85
August	243	179	412	64
September	240	268	303	80
October	163	186	366	86
November	240	236	426	171
December	262	580	889	276
Total for yr	4,272	6,000	7,791	8,797
Av. per month	356	500	650	233

	San Francisco Load, 18.6 kw.	San Francisco Load, 32 kw.	San Francisco Load, 30 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,430	2,350	320
February	963	1,633	670
March	435	1,009	420
April	642	1,181	340
May	270	754	570
June	195	448	470
July	60	39	860
August	67	33	350
September	102	43	100
October	66	62	580
November	191	140	450
December	713	823	450
Total for year	5,134	8,515	5,580
Av. per month	428	709	465

TABLE II—(Continued.)

Completely Electric Homes

	San Francisco 6 Rooms Air Htg., 10.4 kw. Water Htg., 5 kw. Cooking, 7 kw. Lights, 2 kw.	Los Gatos 6 Rooms Air Htg., 21 kw. Water Htg., 5 kw. Cooking, 7 kw. Lights, 2 kw.	Belvedere 7 Rooms Air Htg., 24 kw. Water Htg., 5 kw. Cooking, 8 kw. Lights, 2 kw.	San Francisco 8 Rooms Air Htg., 16 kw. Water Htg., 5 kw. Cooking, 7 kw. Lights, 3 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,640	1,450	1,855	1,581
February	1,146	1,420	1,771	1,888
March	930	1,490	1,517	814
April	1,142	1,000	864	694
May	847	560	872	629
June	885	340	630	643
July	762	180	600	635
August	1,028	590	660	904
September	757	500	708	868
October	575	480	449	874
November	671	660	779	647
December	821	870	1,424	806
Total for yr	11,174	9,530	12,129	10,983
Av. per month	931	794	1,011	915

	San Francisco Air Htg., 19.2 kw. Water Htg., 2 kw. Cooking, 8 kw. Lights, 1.2 kw.	San Francisco Air Htg., 30 kw. Water Htg., 5 kw. Cooking, 8 kw. Lights, ...	San Francisco Air Htg., 13.6 kw. Water Htg., 5 kw. Cooking, 7 kw. Lights, 1.7 kw.	San Francisco Air Htg., 10 kw. Water Htg., 5 kw. Cooking, 8 kw. Lights, 1.8 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,560	3,456	1,237	1,361
February	1,620	2,448	1,307	1,228
March	970	1,776	1,534	1,521
April	840	1,248	1,467	758
May	740	1,008	1,015	913
June	680	1,008	857	1,056
July	500	1,056	473	1,220
August	730	1,056	261	1,743
September	440	1,056	334	1,218
October	580	1,104	667	860
November	890	1,920	999	1,156
December	1,150	2,016	1,164	1,156
Total for year	10,700	19,152	11,315	14,187
Av. per month	890	1,563	943	1,182

Flats and Individual Apartments

	All Electric		Lighting and Heating Only	
	San Francisco 3 Rooms Air Htg., 6 kw. Water Htg., 5 kw. Cooking, 5.6 kw. Lights, 1 kw.	San Francisco 4 Rooms Air Htg., 6 kw. Water Htg., 5 kw. Cooking, 6.5 kw. Lights, 1 kw.	San Francisco 6 Rooms Heating, 12 kw. Lights, 1 kw.	San Francisco 6 Rooms Heating, 6.6 kw. Lights, 1.1 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	391	412	1,680	203
February	397	349	925	64
March	74	746	85	55
April	336	958	83	113
May	324	786	53	102
June	553	352	46	88
July	154	265	98	35
August	158	207	67	66
September	179	225	76	43
October	300	532	71	50
November	295	234	118	92
December	346	316	321	120
Total for year	3,509	5,382	3,623	1,031
Av. per month	292	448	302	86

Banks
Air Heating Only

	San Francisco Load, 31.8 kw.	Oakland Load, 23.6 kw.	Oakland Load, 14 kw.	San Francisco Load, 10.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	2,970	2,558	1,755	1,613
February	2,670	1,672	1,455	1,321
March	1,350	650	446	635
April	1,710	883	377	1,254
May	870	164	237	404
June	420	219	230	382
July	150	59	117	157
August	120	134	85	301
September	0	62	92	308
October	30	300	98	360
November	600	991	178	725
December	1,230	1,769	653	988
Total for year	12,120	9,461	5,723	8,448
Av. per month	1,010	788	477	704

one instance the saving in the installation alone was sufficient to pay the cost of electrical energy for a period of ten years, not taking into consideration interest on investment, cost of fuel, janitor service and depreciation of plant.

Churches

Buildings of this description require heat but a few hours per month with the result that they must nave a system which will quickly heat the whole or any portion of the building. The low cost and flexibility of electric heating systems are particularly adapted to this class of building. The load also may be off-peak in character.

Offices

Employers are recognizing the advantage of supplying properly regulated heat to their employees. Electric heating systems can be regulated uniformly to the temperature where employes work to the highest efficiency. Pure air with uniform heat and proper ventilation without drafts have been proved to increase efficiency from 10 to 25 per cent in many cases. In this respect electricity is superior to other types of heating.

Bath Rooms

An appropriate electric heater for bath rooms is of particular interest and importance. Its practicability has been demonstrated and it has been proved that the matter of rate does not enter into consideration. It is expected that this form of service will pave the way to heavier installations, particularly in those sections of the country where electric air heating is not now well developed.

Because full temperature is desired in a minimum of time it is common practice to install bath room heaters of capacity greater in proportion than those used in other rooms of the house. The tendency seems to be to use, in small bath rooms, heaters of about 1,200-watts to 1,500-watts capacity but there is a growing disposition to extend this to 2,000 watts. Undoubtedly better service will be rendered and greater satisfaction obtained with the use of the larger sizes, even in small bath rooms. The period of use of these heaters is usually very short and the heat result must be immediate.

Bath room heaters are usually of the flush or permanent type with nickel or white enamel finish to harmonize with the fixtures of the room. This type of heater provides the maximum of available space and safety. Even in houses and apartments where other heat is installed there is a growing practice to install an electric heater in the bath room, the heater usually being on the tenant's meter. He thereby pays for the service he requires. This practice, in apartment houses, often results in material saving in heating plant operating costs.

Because of the fact that some power companies require a permanently connected heating appliance of 2 kw. before granting special combination or heating rates, this form of application has a special attraction. Not only because of the revenue from this bath room heater alone, but because of the increased use of appliances where the combination rate is enjoyed, the installation of bath room heaters becomes a matter for serious development by power companies.

Heater Types

Electric heaters are made in flush or permanent types for mounting in the wall, portable types for moving from one location to another, bracket types for fastening on the wall and floor types for mounting beneath the floor, with register set flush in the floor. This latter type is sometimes used for central heating.

Efficiencies of these various types, at the heater, vary only slightly. It is evident, however, that heaters placed within a room will give better heating service than those heaters working through ducts. Electric central heating does not prove efficient because of the conduction losses, even when the ducts are well insulated.

It is ordinarily best practice to install wall or permanent type heaters. Better engineering is usually possible with this type and heaters so mounted become part of the fixtures of the home just as do bath room fixtures. This type of installation, too, increases the property value.

TABLE II—(Continued.)

Churches

	Oakland Load, 30 kw.	Napa Load, 15 kw.	Stege (near Richmond) Air Htg., 27.6 kw. Water Htg., 5 kw. Range, 7.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,530	990	552
February	890	890	336
March	790	520	384
April	508	440	432
May	240	250	288
June	60	90	216
July	0	10	72
August	10	0	192
September	0	10	96
October	70	50	408
November	520	350	912
December	1,300	680	768
Total for year	5,918	4,280	4,656
Av. per month	493	357	338

Stores and Offices—Air Heating

	San Francisco Load, 12 kw.	Palo Alto Load, 16 kw.	San Francisco Load, 26.8 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,464	2,158	3,408
February	1,292	1,850	2,448
March	120	804	792
April	210	768	984
May	108	158	168
June	56	0	264
July	34	0	48
August	41	0	288
September	80	0	120
October	80	625	24
November	495	1,178	576
December	878	2,246	1,968
Total for year	4,858	9,787	11,086
Av. per month	405	815	924

	San Francisco Load, 177.9 kw.	San Francisco Load, 12.4 kw.	San Francisco Load, 38.5 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	23,040	1,516	2,688
February	23,040	820	3,984
March	5,760	731	1,008
April	6,120	522	48
May	3,600	235	96
June	1,680	134	0
July	1,800	9	48
August	2,400	15	0
September	1,200	12	192
October	1,920	53	0
November	3,360	383	144
December	3,960	836	984
Total for year	77,880	5,266	9,192
Av. per month	6,490	439	766

Schools and Academies

	Air Heating		
	San Francisco Load, 14.1 kw.	Clarksburg Load, 117 kw.	Folsom Load, 110 kw.
	Kw.-hr.	Kw.-hr.	Kw.-hr.
January	1,012	5,056	9,200
February	1,218	5,600	7,400
March	614	5,056	2,880
April	791	4,640	2,560
May	777	1,696	600
June	229	512	160
July	175	32	0
August	195	32	0
September	82	64	0
October	217	3,200	80
November	576	2,272	1,120
December	1,313	4,128	6,080
Total for year	7,199	32,288	30,320
Av. per month	600	2,690	2,527

	Esparto Air Htg., 188 kw. 5-hp. Motor Water Htg., 5 kw.	Riverside Load, 44.5 kw.
	Kw.-hr.	Kw.-hr.
January	7,200	5,020
February	8,800	4,740
March	5,520	780
April	3,840	2,560
May	1,680	240
June	1,200	9
July	400	0
August	320	0
September	320	0
October	560	940
November	5,680	3,720
December	6,720	4,660
Total for year	42,240	22,669
Av. per month	3,520	1,889

Investment and Depreciation

Normally the cost of an electric heating installation is much less than that of a first class fuel system. This means a reduced construction cost and a lower carrying charge on the property.

Depreciation of fuel heating systems may be high and labor and maintenance may be considerable items. Depreciation of electric heating equipment can be taken as not exceeding that of the building, and maintenance practically nothing. Labor for operation is nothing. Frequently there are insurance advantages in completely electrified homes.

Thorough Insulation of Buildings

Thorough insulation of buildings is now recognized by all heating engineers and architects as being of primary importance. While it is equally important to insulate thoroughly against heat losses when fuel heating plants are used or when electric heaters are used, only the most progressive of the heating manufacturers are properly emphasizing the importance of such insulation.

If the building is heated with electricity, the bills are rendered monthly, and, hence, the cost of operation and the economy are emphasized monthly when the bill arrives, whereas, with fuel-heating plants fuel is usually obtained twice a year, and the user rarely knows very closely what his actual cost of fuel is.

Savings in fuel costs as high as 40 per cent in relatively cold regions have been effected merely by a slight investment in insulation of the building. According to the U. S. Bureau of Industrial Research the fuel saved by insulating a building will, in three years, pay for the cost of insulation.

Insultion of buildings will help to provide even heat distribution where systems low in convection characteristics are employed.

Calculation of Heater Capacities

It will, of course, be recognized that in calculating the heating requirements for extreme conditions—such as buildings with very high ceilings—judgment must be used as to the compensating factor to be employed. The value of this factor will be materially affected by the convection characteristics of the equipment.

In making calculations as to the size of heaters required to create and maintain proper temperatures, the following must be considered:

1. Area of exposed glass.

2. Area, construction and exposure of outside walls.

3. Area, construction of inside walls and temperature of adjoining rooms.

4. Area, construction of floor and conditions under floor.

5. Area, construction of ceiling and whether attic or floor above.

6. Volume of air in room and number of air changes required per hour.

7. A study of air leakage should be made as this increases the number of air changes.

High-temperature, radiant-reflector type heaters primarily are adapted to heating limited areas rather than for uniformly raising the room temperature, and as the calculations for that type of heating are entirely different from those involved in heating by convection air currents, the following discussion is limited to the subject of convection air heating only.

As the majority of electric heaters are rated in watts all radiation losses will be given in watts rather than in B.t.u. One watt-hour is equivalent to 3.412 B.t.u.

Table I, computed from reliable sources, gives the watts lost by radiation per sq. ft. of surface of different building material for each 10 deg. F. difference in temperature between the room to be heated and the surrounding air.

To calculate the volume of air, multiply the cubical contents of the room by the number of air changes required per hour.

In residences it is customary to calculate two changes of air per hour but where there are many leaks around doors and windows this should be increased.

In schools, churches, theaters, halls, shops, etc., the law requires 30 cu. ft. of fresh air per person, but as each occupant of the room gives off a certain amount of heat, it is only necessary to figure on the heating of from two to four changes per hour according to the number occupying the room.

Where sides of buildings are exposed to winds 10 per cent to 25 per cent should be added to the radiation losses of the surfaces exposed.

When buildings are heated only intermittently with long intervals of non-heating, capacity of heaters should be increased at least 10 per cent. Never install under-capacity heaters as over-capacity heaters will insure greater economy and more satisfactory service.

Method Used

The following examples indicate the method of determining the size of heaters for different types of buildings:

Living room 14x20 ft. with 9 ft. ceiling, having two outside walls, 20 ft. wall exposed to winds. Glass area 75 sq. ft. Frame construction, plastered inside, boarded and plastered outside. Double wood floor, plastered ceiling, no floor above. Two air changes per hour. Difference between outside and required room temperature 30 deg. F.

Refer to Table I under 30 deg. F. temperature difference in order to determine the watt-hr. per sq. ft. for each particular surface.

The following gives the method of making calculations:

(1) .....Glass area × watt-hr. lost per sq.ft.
(2) .....Outside wall (less glass area) × watt-hr. lost per sq.ft.
(3) .....Inside wall area × watt-hr. lost per sq.ft.
(4) .....Floor area × watt-hr. lost per sq.ft.
(5) .....Ceiling area × watt-hr. lost per sq.ft.
(6) Vol. of room × air changes per hr. × watts required per cu.ft.
(7) .....Allowance for exposed area
(8) .....Total watts required

Example 1

Residence

Surface	Area Sq. Ft.			Watt-hr. Lost per Sq.ft.	Total Watt-hr. Lost
(1) Glass		=	75	× 9.0000	675
(2) Outside wall	[(14 + 20) × 9] — 75	=	231	× 3.9000	901
(3) Inside wall	(14 + 20) × 9	=	306	× 1.2000	367
(4) Floor	(14 × 20)	=	280	× .7500	210
(5) Ceiling	(14 × 20)	=	280	× 3.0000	840
(6) Air	(14 × 20 × 9 × 2)	=	5040	× 0.0162	813
(7) Exposed area	(20 × 9 × .25)	=	45	× 3.9000	176
(8) Total watts required					3,982

It will be noted that the watts required in this room are 1.58 per cu. ft.

In making the calculations for residence heating, each room should be figured separately. However, for quick estimating it is usually safe to figure 0.55 watts capacity for each 10 deg. F. difference in temperature between room and outside air. This rule is only roughly approximate and does not hold true, however, under abnormal conditions or where the volume is less than 1,000 cu. ft. or greater than 5,000 cu. ft. As the volume increases the watts required per cu. ft. will become less. This is due to the radiating surface not being increased in direct proportion to the volume.

Office Buildings

In the case of office or other buildings having a large number of rooms unless it is a definitely known fact that all rooms are to be heated and used at all times, each room should be treated separately, and losses computed for the inside walls as well as the floors and ceilings. This will always result in the installation of much larger capacity heaters than would be installed if a steam plant were used, but it is desirable for the reason that the electric heat is used differently from steam.

In the case of a steam plant, when the heat is on the complete building is usually heated regardless of whether or not all rooms are occupied, so that interior wall and floor and ceiling losses can be eliminated. Furthermore there is little or no possibility of regulating the steam radiators other than the difference due to the greater or lesser radiation caused by the difference in the room temperature and the radiator temperature. Naturally as the room temperature increases the difference of temperature between the air, the walls and the objects in the room and that of the radiator becomes less with a resulting diminished heat transfer. Where an electric heating system is installed it is not customary to heat rooms not occupied and since electric heaters are almost always controlled by three heat switches the heat can be easily controlled, and it is usually more economical to install heaters of ample capacity so that individual rooms can be quickly heated on high heat and then turn the heaters down to medium or low as may be required to maintain the desired temperature. The electric heater does not possess the same characteristic as the steam radiator described above, but will continue the heat transfer at the same rate regardless of the increasing room temperature for the reason that the heating coils will rise in temperature and thus maintain approximately the same temperature difference.

When it is necessary to compare electric heater sizes with those of steam or hot water radiators for the same building, and while it is a known fact that radiators vary according to construction, surface of heater and pressure, the following table will give a fair average for comparison:

1 sq.ft. of steam radiator at 4 lb. pressure.....70 watts
1 sq.ft. of steam radiator at 10 lb. pressure.....80 watts
1 sq.ft. of hot water radiator at 180 deg. F.....45 watts

Method of Calculating Energy Consumption

The records of the nearest weather bureau will give the hourly temperature for the year. For rough calculations the mean monthly temperatures during each of the heating months over a several-year period may be taken as an average. To estimate the consumption for any month subtract this mean temperature from the desired temperature and divide by the maximum temperature rise figured. Multiply the heater size by this factor and by the number of hours that heat will be required.

TABLE III—Average monthly and yearly temperatures, San Francisco, California.

	1926	1925	1924	1923	1922	1921	1920
January	47.9	51.4	50.2	48.1	46.8	49.5	52.0
February	56.0	55.2	57.0	52.2	50.2	52.9	52.8
March	60.6	55.4	54.5	56.8	52.4	54.6	52.6
April	61.6	57.0	57.4	56.1	53.5	54.9	54.9
May	61.0	59.0	59.1	57.2	58.0	54.4	55.8
June	59.2	60.7	59.8	57.2	60.0	62.4	60.0
July	61.1	61.2	59.0	60.8	60.2	59.8	57.8
August	60.8	61.2	59.1	60.6	60.4	59.6	60.0
September	61.2	62.7	62.4	64.0	63.4	63.3	64.0
October	63.4	62.2	59.4	62.5	60.6	61.5	60.2
November	60.9	56.6	57.2	60.8	54.3	57.8	56.2
December	51.5	51.2	47.8	51.0	50.6	53.0	51.0
Average	58.7	57.8	56.9	57.2	55.8	56.9	56.4

As an example, an installation is figured to give 40 deg. F. temperature rise (30 deg. F. to 70 deg. F.) and the mean temperature for a given month is found to be 50 deg. F. The average temperature rise is, then, 20 deg. F. (70 deg. F.—50 deg. F.) If a 5-kw. heater adequate to give a 40 deg. F. temperature rise was installed in a room and the room was heated daily for eight hours per day, 25 days per month, the consumption would be:

$$5 \text{ (kw.)} \times \frac{20}{40} \text{ (factor)} \times 8 \text{ (hr.)} \times 25 \text{ (days)} = 500\text{-kw-hr.}$$

The result obtained in this manner would be high as the mean temperature taken above is the mean for the 24-hour period and the mean for the heating period would be higher as it is warmer during the heating hours than the average for both day and night. Allowance must also be made for the heat derived from the sun, which is of great importance.

It is impossible to make an accurate calculation of the monthly consumption of any particular building due to the variations in construction, temperature and heating requirements, but from a close observation of several installations in the San Francisco Bay section, all of which have been installed for some time, and on which very accurate data have been compiled, it has been found that the following are very fair averages.

TABLE IV—Average monthly and yearly temperatures, Fresno, California.

	1926	1925	1924	1923	1922	1921	1920	Normal*
Jan	43	48	47	46	42	46	48	46.3
Feb	54	54	56	50	50	52	52	51.1
Mar	61	57	54	57	53	57	53	55.0
Apr	66	61	62	59	57	59	59	60.1
May	70	69	73	67	69	64	68	67.1
June	80	77	77	69	76	76	75	75.7
July	84	84	80	80	84	84	79	82.1
Aug	80	79	80	79	79	80	82	80.7
Sept	72	69	75	76	79	73	72	73.3
Oct	67	63	62	64	64	67	60	64.0
Nov	61	54	55	58	51	57	54	54.2
Dec	47	46	45	46	50	48	48	46.3
Av	65	63	64	63	63	64	62	63.0

*39 years' average.
Copied from U. S. W. B. Records.

Typical Energy Consumption

Residences—Consumption per month for six winter months, where a uniform temperature was maintained, averaged 20-25 kw-hr. per kw. of heater capacity installed.

Offices—Consumption per month for six winter months, heating eight hours per day, 26 days per month, averaged 50-60 kw-hr. per kw. of heater capacity installed.

Schools—Consumption per month for six winter months, heating five hours per day, 20 days per month, averaged 35-40 kw-hr. per kw. of heater capacity installed.

Do not attempt to compare the operating cost of electric heating systems with those of other heating systems by means of the B.t.u., given off by combustion of other fuels as it is an unfair comparison due to the fact that the efficiency of other systems can only be estimated, and to the further fact that these comparisons are usually made under ideal conditions, which conditions do not prove normal and correct under actual tests over long operating periods. Furthermore, this efficiency decreases, in fuel operated systems, as plants are operated at less than full load. The only proper comparisons are derived from the results of satisfactory installations.

In determining the actual cost of any heating system the following must be taken into consideration:

1. Interest on initial investment.
2. Insurance on plant.
3. Depreciation of plant.
4. Labor required to operate plant.
5. Repairs necessary to keep plant operating.
6. Cost of fireproof room and necessary flues.
7. Actual cost of fuel.

The flexibility of electric heating systems, which permit heating any room without the need of operating the entire heating plant, also, the ease with which the heat may be regulated, must be given careful consideration.

Ventilation

Although it appears to be a general custom to ventilate rooms from the ceiling or by opening windows, this is the most costly and least satisfactory means of ventilation. Hot air, being lighter than cold air, rises and is carried to the outside atmosphere while foul air is heavier than fresh air and falls to the floor level. It is not always a simple matter to ventilate rooms from the floor without mechanical means. The cost, however, is much less by using electric energy to drive an exhaust fan for ventilation than to use heated air to create a draft.

Location of Heaters

Heaters should be placed generally in such a manner as to cause air currents to move away from windows rather than towards them. Wall or bracket type heaters should be placed only a short distance from the floor. Long or large rooms should be provided with two or more heaters located as far apart as convenient. It is obvious that better heat distribution will be realized from two heaters in a room than from one heater.

Humidity

This is a very important factor in the East and Middle West where the temperature is often around the zero mark and the percentage of moisture in the air is very low. However, on the Pacific Coast during the heating period the percentage of moisture in the outside air is high, and as the difference in temperature is not great, the outside air when brought up to room temperature usually contains a sufficient percentage of moisture so that it is not necessary to add to it.

Comparative Operating Costs

The average annual fuel cost in a completely electric six room home, as compared to a non-electric home, based on an analysis of several hundred homes in California follows:

Completely Electric

Electric lighting	$ 30
Electric cooking	60
Electric water heating	70
Electric air heating	110
Electric refrigeration	20
	$290

Mixed Fuels

Electric lighting	$ 30
Cooking fuel	40
Water heating fuel	60
Air heating fuel	80
Ice	25
	$235

The difference in cost with complete electric equipment as against other methods will be only $4 to $5 a month additional, which is more than offset by the advantages enumerated elsewhere.

The average annual cost of furnace oil is from $40 to $50 per year. Such installations offer some hazard as regards fire and explosion, even when a high grade burner is installed. The average cost of such installations in an eight-room home including furnace, oil burner, storage tank, etc., is in the neighborhood of $1,200. An electric system for the same house will cost about one-half to two-thirds of this amount. The much smaller cost of electrical installation will offset, for a number of years, the higher operating costs of electric heating. In addition, burners are prone to clog, become fouled with soot, and due to numerous mechanical devices, are subject to considerable depreciation owing to the high temperature in the furnace and always the possibility that the safety device will not be operative at a critical time. This is particularly true in homes where the equipment is given no attention, expert or otherwise.

Some Data on Energy Used in Existing Installations

Table II presents the kw-hr. consumption of a number of homes, apartments, offices, schools and banks using electricity exclusively for cooking, water heating, air heating, lighting and appliances.

Power and Heating Committee Reports[1]

Electric Truck Activities*

In the report of the Electric Truck Committee presented at the 1926 convention of the association, an outline of the previous activities was included. Inasmuch as this review was published in the convention proceedings, this committee does not deem it necessary to present a complete resume of previous activities except such of those as may have a direct bearing upon the field covered by the report submitted herewith.

In 1924, effort was directed to interesting central stations in the desirability of battery-charging load. This same idea was carried out in 1925 when a series of letters was forwarded to central station executives and department heads.

In the 1926 report, confidence in the ultimate future

* **Report of sub-committee.—K. I. Dazey, chairman:** L. F. Boerner, vice-chairman; W. J. Walsh, secretary. A. J. Anderson, J. J. Canavan, H. D. Esterbrook, J. L. Farley, H. K. Griffin, E. A. Hunt, M. P. Lohse, C. L. McWhorter, J. F. Moulton, I. G. Perin, P. P. Pine, Carl Seger, G. F. Wakeman.

[1] **W. C. McWhinney,** Southern California Edison Company, chairman. **A. M. Frost,** San Joaquin Light & Power Corporation, vice-chairman. **Canavan Motors Corporation:** J. J. Canavan. **Coast Counties Gas & Electric Company:** E. D. Murray. **Coast Valleys Gas & Electric Company:** P. S. George. **Commercial Truck Company:** K. I. Dazey. **Everhot Electric Sales Company:** H. H. Fogwell. **Edison Electric Appliance Company:** G. W. Cole, L. A. Frances. **Edison Storage Battery Company:** G. F. Wakeman. **Electric Storage Battery Company:** L. F. Boerner. **Elwell Parker Company:** I. G. Perin. **General Electric Company:** E. J. Cipperly, E. A. Hunt, C. R. Owens, M. Rhine. **Great Western Power Company:** O. F. Anderson, H. E. Brillhart, J. F. Moulton, W. J. Walsh, J. W. Wrenn. **J. H. Knapp Company:** J. H. Knapp. **Los Angeles Bureau of Power & Light:** E. V. Kane. **Los Angeles Gas & Electric Corporation:** Frank Weiss. **Mercury Tractor Company:** A. J. Anderson. **Ontario Power Company:** F. L. Allen. **Pacific Gas and Electric Company:** W. R. Adams, W. P. Baer, J. L. Farley, W. F. Neiman, W. C. Schafer. **Pacific Scientific Company:** D. G. McAllister. **Philadelphia Storage Battery Company:** C. L. McWhorter. **San Diego Consolidated Gas & Electric Company:** P. P. Pine. **San Joaquin Light & Power Corporation:** M. P. Lohse. **Southern California Edison Company:** W. L. Boxall, R. H. Cates. **The Southern Sierras Power Company:** Geo Bigelow, E. B. Criddle, D. B. Wheelock. **Valley Electrical Supply Company:** H. H. Courtright. **Walker Vehicle Company:** Carl Seger. **Western States Gas & Electric Company:** H. K. Griffin. **Westinghouse Electric & Manufacturing Company:** H. D. Esterbrook, Max Lee, C. R. Sullivan. **Miscellaneous:** J. R. Gearhart, W. F. Sutor.

of electric transportation was expressed, and the committee also expressed the conclusion that such development was largely contingent upon the recognition and support of central stations.

There are no outstanding features or special activities during the past year warranting emphasis. The committee finds that the volume of electric truck business during the past year has been highly disappointing, and it was decided to attempt a co-operative analysis of the existing conditions to ascertain, if possible, what can be done to bring the electric truck into its proper place of recognition, and map out a program to this end.

With these ideas in mind, letters were addressed to central station executives, executives of truck and battery manufacturers, and to the local representatives of the truck and battery companies.

It was the desire of the committee to obtain the advice and counsel of men of broad business experience and executive ability, at the same time bringing to their attention a condition, in the correction of which, we felt they would be vitally interested.

Generally speaking, their replies were disappointing in that they did not aid in a solution of our problem; and the fact that many of the letters sent out remain unanswered, indicates a lack of the very interest which we were endeavoring to arouse.

Perhaps it would be well to summarize from the answers which have been received, and, if possible, form a composite view of the situatoin. In reply to inquiries made to the central station executives, the following is submitted:

Question 1. Do you consider the battery-charging load as a source of desirable revenue?

Without exception, the companies responding agreed that this is a very desirable class of revenue.

Question 2. Do you believe that the territory served by your company offers a good field for electric transportation? (If not, will you be good enough to submit your reasons?)

Replies to this question would appear to indicate that many of the central stations recognize the territory which they serve as affording a good field for electric transportation. It would also appear, however, that other companies serving smaller communities feel that their particular territories are not conducive to electric transportation. The committee, however, believes that in some instances the opinions so expressed have been reached without a full consideration of the possible development of this class of business.

Question 3. Has any particular sales effort been made in the past by your company in promoting electric transportation?

With the exception of two central stations, it would appear that there has been practically no sales assistance rendered in recent years, and we believe that unless there is a more general recognition given and sales assistance rendered by the central stations, the continuance of the Electric Truck Committee is largely a waste of time and effort.

Question 4. In a general way, what has been the result of such effort?

It appears to be the consensus of opinion that sales assistance in the past has not justified itself by the results. In comparison with other types of energy-consuming devices for which there would appear to be a more ready market, undoubtedly the added revenue per dollar of sales investment is greater. This, however, is materially offset by the improvement in the load factor as a result of the addition of the battery-charging load.

Question 5. Do you believe in electric transportation in your own company where suited to your conditions?

The majority of replies to this question dismiss the subject with the statement that electric trucks are not suitable to their conditions. The committee is heartily opposed to the use of electric trucks outside of their logical field, yet we believe with equal heartiness that a more careful analysis of central station transportation operation would disclose many logical and economical electric truck applications.

Question 6. Have your operating departments been officially requested to give the electric truck an "even break" as against other types of transportation equipment?

From most of the replies received it is apparent that this co-operation has not been requested. We believe that the only way in which this co-operation can be secured is expressed in the following statement from a central station representative in answer to this particular question.

"I am not convinced that the transportation department of our company has been sold to an active interest in the use of electric trucks where they might be suitable. This could undoubtedly be overcome by pressure from above."

The committee feels that the preceding statement explains whatever lack of co-operation may exist along the lines of central station usage and support.

Sales Resistances

The following are presented as representing the composite of sales resistances as submitted by the central stations, manufacturers and manufacturers' local representatives.

A. High initial cost—While in comparison with the cheaper priced and lighter types of gasoline trucks, the initial cost of the electric truck is unquestionably greater, when used in their proper field of operation, the overall cost more than offsets this difference, due to lower depreciation, economy of operation and dependability of service. One of the greatest difficulties in overcoming this price resistance is an absolute lack of anything approaching uniformity in the cost accounting for vehicular operation. Much educational work is necessary along these lines, and we believe that central stations can (if they will) render much valuable assistance in the study of the transportation conditions of their customers.

It is interesting to note that this deterrent factor is presented by central stations and is discounted by electric truck salesmen.

B. Charging equipment—The necessary investment in charging equipment might properly come under the heading "high initial cost" of electric trucks. Many central stations, however, have adopted a liberal policy in this regard, and in some of the larger centers of population, available d.c. service greatly reduces this sales resistance.

C. Intense activities of gas truck salesmen—With the tremendous activities of gas truck interests, it is but natural that the electric truck and battery companies cannot hope to entirely offset these activities, which result in a consideration of transportation in terms of gasoline trucks. Right here is where the whole-hearted support of central stations is vital if the industry is to thrive and a volume of battery-charging load is to be added to central station lines.

D. Lack of knowledge—Even in the replies received from the central stations there is a decided indication of a general lack of knowledge of a major energy-consuming device. If the central stations who are, or should be, vitally interested, are without the proper knowledge of electric truck operation, how can it be expected that a disinterested transportation user can be convinced under the present unequally balanced solicitation? It cannot be said that this committee, or any previous committee, has failed to follow up central station transportation business in behalf of the electric truck.

Ignorance may be compared to darkness, and the whole-hearted and co-operative support of all central stations is essential if the electric truck and battery companies are to continue in their efforts to shed the light of knowledge to transportation users.

E. Lack of range and speed—This objection is quite logical in theory, but when it is dissected and considered in conjunction with the approved application to and use of electric trucks in their proper field, the very fact that it is presented as a resistance causes us to revert to the previous paragraph on "Lack of Knowledge."

With respect to cruising range, more than 75 per cent of city transportation comes within the logical and economic field of the electric truck. Very few concerns keep mileage records, and where prospective users of electric trucks are persuaded to meter their actual mileage (which they generally refuse to do), the actual distance of daily operation is invariably less than half of the distance estimated by the transportation user who advances the sales resistance that the electric trucks have not the necessary range.

With respect to speed, we are again confronted

with a general lack of knowledge. Because of the high maximum speed of gas trucks, it is almost universally accepted that electric trucks are slower. While admittedly, the most logical electric truck field is in the frequent stop service, actual comparative tests taken by the automotive department of the Pacific Gas and Electric Company (the results of which were given on page 43 of the 1925 proceedings) proved that with a daily mileage of 18, and an average of only one stop per mile (both hilly and level operation), the electric truck actually averaged one mile per hour better speed than the gas truck.

In actual stop-watch tests in milk deliveries in San Francisco and Oakland, with total time en route of 5½ hr. with gas trucks, the electric trucks were able to cover the same distance in 4½ hr.

Wherein, we ask, lies the slow speed of the electric, except in the prejudiced mind which is closed to knowledge not in accord with preconceived ideas?

F. Unwarranted public prejudice—Whatever prejudice exists is due to lack of knowledge or to previous unsatisfactory experience due to unwise or improper applications. The first phasé we have already discussed. The latter will be considered under "past sales errors," paragraph M.

G. Lack of battery-charging facilities—We believe that the extent to which this is a factor is debatable. A study of past conditions does not indicate that this is a vital factor on the Pacific Coast. With a steady growth in the number of electric trucks used, we believe that there will be a corresponding growth in battery-charging facilities; in other words, the law of supply is predicated upon the law of demand.

H. Laying up trucks for charging—Under normal conditions of operation such as obtain in this territory, and where the sale of electric trucks is confined to their proper and economical sphere, truck batteries can be charged during out-of-service hours. Where a truck is operated for two, or even three shifts, batteries can be inter-changed in the same time as it would require to gas and oil a gasoline truck.

We view this in the light of a resistance which exists only in the minds of those who are not fully acquainted with the merit of the electric.

I. Lack of mobility—We consider this objection to be quite an important one. There are many transportation users whose normal service is within the proper field of the electric, yet who may infrequently require a long operating range. Depending upon the size of the fleet operated, we know of many instances where a mixed fleet of electric and gas, or the maintenance of one or two gas trucks to meet such emergencies, solves this problem satisfactorily, the economies of the electric more than offsetting the investment in such emergency equipment.

On the other hand, our study has convinced us that generally the operation of vehicular equipment in the Pacific Coast territory is not based upon logical or economic routings. There is much unnecessary overlapping of routes and an utter lack, in most cases, of scientific routing, resulting in an unnecessarily larger operating radius and correspondingly higher operating costs. With the increasing tendency towards scientific transportation analysis, we believe that these conditions will be gradually overcome, and that an improved field for the electric will offer.

J. Driver opposition—Without question, there is an initial prejudice on the part of the drivers, but this is rapidly overcome in most instances by the driver himself through a recognition of the ease of operation of the electric, and that he is often able to complete his day's work sooner with less expenditure of physical effort.

Invariably, the driver who retains his prejudice against the electric is the man who drives his gas truck at a high rate of speed; the same driver equally resents the use of a governor on his gas truck.

All too often the driver is permitted to feel that the electric truck is only an experiment.

We might answer the driver opposition by asking the prospective user of electric trucks whether or not he bought his equipment on the personal belief or prejudice of his driver, or whether he purchased on the basis of securing the greatest value to himself to meet efficiently and economically his own operating conditions.

K. Pacific Coast Conditions—With the rapid growth of the Pacific Coast territory, which relatively outdistances many of our Eastern States, we have today in our midst many large enterprises which a few short years ago were business babes. This phenominal growth has necessitated the expenditure in business expansion of untold millions of dollars, and the progressive business of today on the Pacific Coast often finds that its natural demands for expansion to meet the changing conditions stretches its capital to a point where expenditures for more economical and efficient appliances are necessarily deferred. Frequently the assured return from the business expansion is greater than the economy which could be effected by devoting the same money towards the initial purchase of more expensive though more efficient equipment.

We believe that these conditions have in the past and will in the future, retard the development of electric transportation on the Pacific Coast to a far greater degree than in the Eastern states where industry has, through many more years of steady growth, become more stabilized.

L. Low gasoline costs—Comparing the prices of gasoline with Eastern prices, and comparing the average rate for electricity, would indicate that the low cost of gasoline on the Pacific Coast has no bearing on the use of electric trucks, and we believe that the price of gasoline must reach heretofore unknown levels before this will prove a factor.

M. Past sales errors—Both with central stations and with disinterested users of vehicular equipment, improper application of electrics in the past through ignorance on the part of the salesman, or because of the desire to earn a profit for today without the thought of tomorrow, has built up a real and almost impregnable resistance to sales. While gas truck companies also have been guilty of misrepresentation, and many have passed out of existence because of such short-sighted policies, the transportation user does not blame the gas truck manufacturer or salesmen for his own sins, the sins of his predecessor, or of his contemporary, yet are prone to close their minds to an intelligent consideration of the improvement in and the simplification of electric truck mechanism, the notable improvement in storage batteries, and the broad-gaged policies which exist with the electric truck manufacturers in the proper marketing of their products.

It requires persistency of effort, establishment of both company and personal confidence through dealings with transportation users, to enable truck and battery representatives to successfully scale the barrier of past errors and work hand-in-hand in an efficient manner in the proper education of the transportation used. It also requires 100 per cent central station co-operation.

N. Lack of sales effort by truck and battery salesmen—We must recognize the fact that a portion of the blame for existing conditions rests squarely on the shoulders of the truck and battery companies and their salesmen. There are many contributing causes for this condition.

O. Lack of confidence on the part of the electric street truck salesmen—That this is a just criticism does not permit of argument, yet in fairness we must concede that continued and unsuccessful knocking at barred doors is not conducive to the maintenance of that high degree of confidence which is so essential in the marketing of electric trucks.

P. Lack of teamwork—This criticism is also unquestionably true. Business has been very scarce indeed, and this lack of volume has, in all probability, resulted in some instances in destructive competition.

Q. Failure of central stations to use electric trucks where feasible—We consider this a real stumbling-block to the successful marketing of electric street trucks, and past reports to the association have urgently commended (but without any appreciable effect) the electric street truck to the attention of the executives, operating heads, and sales departments of central stations.

R. Lack of continued and consistent sales assistance by central stations—This is a condition and not a theory, and the committee believes that until such time as there is a more general recognition given to and sales assistance rendered by the central stations, comparatively little progress will be made.

S. Lack of co-ordination in sales effort—We cannot lay too much emphasis upon the urgent necessity of

co-ordination of sales activities, and by co-ordination we include the mental and physcal foirces of the entire industry, from the manufacturers of electric trucks, the manufacturers of its component parts, the truck salesmen, the battery company representatives, and so on down to the ultimate user and driver. It has been found, however, that where a great number of electric trucks have been sold, it is only through the intelligent aid and co-operation of the central stations.

T. Lack of quantity production—This is a deterrent affecting cumulative sales and usually resulting in high initial cost. It is not stressed as one of the most important factors, and it is worthy of note that even the electric truck and battery salesmen who meet the transportation user, do not consider the initial cost of electrics as being a governing factor.

U. Guaranteed maximum cost of operating gas trucks—In the last two or three years several contract companies have entered into long term agreements with transportation users for the maintenance of gas vehicular equipment at what would appear to be ridiculously low rates. The charges for this service are based upon the economies of large volume and the savings brought about by tremendous purchasing power. The rates quoted for this service compare favorably with the cost of operating electrics, although if the electric truck fleets were maintained on the same basis of numerical units, the economies of electric truck operation would be apparent. There are not, however, a sufficient number of electric trucks in general use to enable such an arrangement to be made.

V. Parcel delivery companies—Many of the larger stores have contracted for their deliveries. Where these contracts are entered into they are usually over periods of time which do not warrant the investment in equipment for the length of life of the electric truck, and the companies who have entered into this field have been primarily interested in curtailing their capital output. Eventually, with the stabilizing of these contracts, the economies of the electric truck cannot be ignored.

W. Price wars and consolidations—Particularly in food commodity lines have these conditions obtained, resulting in many instances in the purchasing of large fleets of cheaper gas equipment to meet temporary conditions of competition, with the result that large numbers of idle trucks have been thrown on the market when eventual consolidations take place.

Industrial Truck Executives

As compared with the lack of development of the electric street truck, the industrial truck executives view the situation with less concern, and the following brief comments are submitted with respect to this class of business:

1. **Frame of mind of prospective user**—The following comment from an electric truck executive covers this point fully:

"Then there are certain localities where the industrial truck is accepted, but there are other localities and industries where just as much effort is being expended to get business and still results are very meager. In other words, we think there is something else besides advertising and sales effort, and that is that a concern or territory must get in a frame of mind where they feel it is necessary to give consideration to all possible equipment for cutting production costs or else they are going into production on such a scale that they cannot get along without the most modern types of material handling machines."

2. **Pacific Coast Conditions:** It has been pointed out to the committee that manufacturing conditions on the Pacific Coast, as compared with Eastern cities, have not developed to the point necessitating economic and efficient shortcuts. We believe that this presents a real psychological reason for the relatively fewer number of electrical industrial trucks on the Pacific Coast.

3. **Volume of business fairly satisfactory:** It would appear that many of the industrial truck companies are fairly satisfied with their present volume of business, particularly in view of the prevailing conditions above recited.

Views Expressed by Local Representatives of Industrial Trucks

1. **Lack of effort:** We belive that this condition is attributable more to the general situation rather than to lack of interest.

2. **Growing use of belt conveyors in canneries:** The canning industry is one of our largest, and in this industry it has been found that the proportion of work which can be done economically by electric industrial trucks is relatively small.

3. **Industrial plants smaller and not adaptable to electrics as compared with Eastern plants:** Many of our industries are smaller than similar Eastern industries and the haul, generally speaking, is shorter and in many cases does not warrant the use of electrics.

4. **Dock loading conditions:** On the docks and piers most of the loading is done through the hatches as compared with a great proportion through side ports in the East. This means that locally, the electric truck can only bring the load to the ship's door and does not take it into the ship, thus minimizing the number of electric truck applications. Where side ports are used for loading, electric trucks are more generally used.

5. **Inadequate elevator capacity:** In many of our warehouses where electric trucks could be economically used, the elevator capacity, both in space and load, is inadequate for this work. It has been suggested that central station engineers bear this in mind when contacting architects and construction engineers.

6. **Lack of courage to adopt new methods:** We do not believe that the people of the West are lacking in courage, as is evidenced by their pioneering spirit in many lines of activity.

7. **Movement of materials considered as a necessary evil:** We believe that this one factor has a great deal to do with retarding the use of electric transportation. In time, competition and scientific analysis will do much in overcoming this condition.

While the report of the committee deals at great length with the street truck problem, it would appear that this phase of electric transportation is the one needing most discussion, as the industrial truck is apparently enjoying a fairly favorable volume of business in this territory. The chief reason why there is less sales resistance with industrial trucks is because of the fact that there is a very definite and substantial labor-saving accomplished which can be readily demonstrated. In the case of the street truck, however, the saving is not so much of labor and is not so apparent or convincing, particularly in the absence of cost records. Again, with the industrial truck, we have a definitely known field of operation as well as fixed labor savings.

Sales Made in 1926

From the reports received form interested sources, it would appear that a total of 66 electric trucks and tractors were sold during the year 1926 in the state of California.

This is a falling off of approximately 33⅓ per cent as compared with the year 1925 when 98 trucks and tractors were sold in this territory. All of this loss occurs with the street trucks.

Something must be done if the electric truck companies are to continue their efforts.

Conclusions

The committee views with real concern the present situation affecting the electric street truck. We believe that, in the main, the criticisms which have been directed by one branch of the industry against another branch, and the self-imposed criticisms, are all too true. There has been an absolute lack of co-ordinated effort, and we consider this to be the principal stumbling block in the way of added sales of electric trucks. True, there are other contributing reasons, but we believe these to be of a minor nature which could very easily be overcome if all those who are, or should be, interested in the promotion of electric transportation lend their aid. With their sincere collaborative effort these obstacles can be overcome.

We believe, for example, that if all the public utilities were to accept and promote the electric truck in its proper field, the lethargic attitude of truck and battery salesmen would be dissipated.

We also believe that much can be accomplished by the storage-battery companies if, instead of advertising the technical merits of their respective types of batteries, they would spend the same effort and money in the broad promotion of electric transportation; they would serve to dispel in the minds of prospective users the thought that the storage-battery is a highly complicated piece of machinery. Even the committee, from some of the advertisements read, and assuming an absence of knowledge of electric transportation, would decide on the use of gasoline trucks rather than run the risk of buying something concerning which there was no concordance of opinion. We believe that intelligent advertising by the battery companies of electric transportation would be of tremendous aid in keeping this factor before the public eye.

The committee also feels that there should be closer co-operation between and among the individual truck and battery representatives, and that these contacts should be on the basis of the highest business ethics. We believe that dissension in the ranks has proved a substantial deterrent.

In conclusion we must reiterate the thoughts which have permeated this report because we believe that today's ailment is directly attributable, not so much to business conditions, not so much to the restricted field of the electric, not so much to the initial high cost, nor to many of the other sales excuses,—but to the single outstanding fact that there has been an utter lack of general co-operation and co-ordination. Unless this condition can be remedied, the committee feels that the day when electric trucks will be sold in volume in this territory, when the battery companies will enjoy a healthy business, and when central stations will profit from a splendid volume of off-peak battery-charging load, will only dawn when the conditions above recited have been corrected.

We believe that leadership is essential in any co-ordinated movement, and we sincerely believe that the only leadership which will prove effective is that of a co-operative promotion, not by one central station, but by all of them.

Industrial Heating*

The work of this committee this year has been carried on along entirely different lines than that of previous years. Instead of preparing a number of papers, it was thought advisable to make better contact between the central station organizations and the users of electric heat.

Since the central stations now have men in charge of industrial heating it was felt that much valuable information could be placed in their hands. The work this year was laid out with the one thought in mind, namely to familiarize those interested in the application of electricity for heating with the feasible applications that could be made without too much missionary work.

The following committees were formed:

Demonstration, Display and Data Committee

Max H. Lee, sub-chairman, reported a meeting held by the district managers of the Southern California Edison Company at which time a talk was given by E. J. Cipperly, industrial heating specialist of the General Electric Company on the subject of "Selling Industrial Electric Heating." This talk was illustrated with a number of lantern slides. A second talk was given by Mr. Lee on the subject of "History and Development of Industrial Electric Heating."

On March 4 Mr. Lee reports a tour of inspection being made by a number of the central station men to various industrial plants where installations of industrial electric heating have been in operation for a period of years. Much favorable comment was heard during this inspection trip and much information was gained by this method of displaying equipment in operation. An additional inspection trip will be made before the convention is held, making it possible for a great many more central station men to become familiar with the electrically heated equipments in operation.

C. R. Owens, industrial heating specialist, General Electric Company, San Francisco, sub-chairman, reported for J. L. Farley of the Pacific Gas and Electric Company, that considerable information and data was collected in connection with installations in San Francisco, together with a number of photographs for distribution to the central station men. Inspection trips such as were held by the members of the Committee in Southern California are planned in San Francisco and Oakland.

Members of this committee will supply the publication committee with about 15 large-size photographs of installations of various applications of electrically heated apparatus, together with data as to connected load revenue over a period of years, both in kw-hr. and dollars and cents.

Publication Committee

E. V. Kane, Bureau of Power and Light, Los Angeles, California, sub-chairman, reports the loose leaf publication which was distributed last year by this committee is being revised and new information and photographs sent to the 25 central stations holding copies of this book.

Visiting Committee

H. H. Fogwell, Everhot Electric Sales Company, Los Angeles, sub-chairman, reports of a number of visits to the various central stations in Los Angeles in connection with the Industrial Heating School held by the N.E.L.A. at the General Electric Company's factory this year. The object of the visit was to interest the central stations sufficiently in this type of business to convince them of the necessity of sending heating men back to attend this year. The result of this work was that one of the central stations in Los Angeles would send a man back this year. This is the result of a number of years' work with a similar committee with this one thing in view as it is necessary that a man have special training in order that he may carry on this work in the proper manner. The committee feels that this company is taking a very logical step in order to handle this work properly.

C. R. Owens, industrial heating specialist, General Electric Company, San Francisco, reported that a number of visits were made to the central stations in and about San Francisco in view of sending some of their men to this school, but while no assurance was given that any men would attend this school this year, it is thought that next year perhaps two men will be sent back to the 1928 school.

Publicity Committee

W. L. Boxall, Southern California Edison Company, Los Angeles, reports that arrangements are made to display a number of large photographs of installations of industrial heating equipment. This display will be made at the convention.

C. R. Sullivan, Westinghouse Electric & Manufacturing Company, San Francisco, sub-chairman, reported that a number of photographs have been taken in San Francisco territory which will be enlarged and displayed at the convention.

* **Report of sub-committee.—E. J. Cipperly, chairman.** W. L. Boxall, C. B. Criddle, J. L. Farley, H. H. Fogwell, J. R. Gearhart, E. V. Kane, J. H. Knapp, Max Lee, M. P. Lohse, D. G. McAllister, C. R. Owens, P. P. Pine, C. R. Sullivan, W. F. Sutor, W. J. Walsh, Frank Weiss.

Competitive Power and Isolated Plant Load*

A survey of isolated plant load in the territory served by the member companies of the P.C.E.A. is being conducted by the competitive power committee, and probably will be completed before the end of the present association year. When finished, the report will be sufficiently complete to give all data on isolated plant installations in the territory.

The survey will tabulate the following data covering the systems of all class A members:

Name of consumer.
Location of plant.
Class and branch of industry.
General application of power.
Total hp. in operation in plant.

* **Progress report of sub-committee.—W. C. Schafer, chairman.** W. P. Baer, M. P. Lohse, M. Rhine, D. B. Wheelock.

Estimated load factor and operating hours.
Kw. or kva. capacity of private generator or hp. of engine.
Connected load served by private source of power.
Connected load served by central station.
Remarks covering special operating conditions.

The results should be sufficiently complete to justify the present committee or its successor in specially preparing the data in a handy form for ready reference by utility salesmen in the field.

Throughout the year the committee has furnished data for the files of the N.E.L.A. competitive power committee at the request of the chairman, H. W. Derry. Also it has received and read the various reports and articles prepared and sent out by the national committee.

Engineering Section[2]

Accident Prevention Committee Reports[1]

Educational Publicity*

By S. M. BULLIS

Accident prevention without publicity is much like the proverbial light under a bushel. The electrical industry is pretty well convinced of the necessity of popularizing the work and one of the great problems now remaining is to educate the public, not merely for its protection, but for our own protection. Every accident means another rent to be repaired in our cloak of public relations.

Educational publicity on accident prevention takes three forms. It may be constructive in the advocacy of safe methods and in first aid. It may be informative in that it seeks to present the correct picture of an accident or a condition to the public. It may warn of hazards.

Channels

Publicity may be secured through newspapers and magazines in their reading columns, through the medium of paid advertisements, illustrated bulletins, pamphlets, instruction books, or through talks and lectures. Newspaper propaganda perhaps is the most far-reaching. In accident prevention work it seldom is necessary to resort to paid advertisements for the reason that public interest has been so aroused by the slogan "Safety First" that newspapers usually will accept items on the subject.

The publicity man in company organizations is a valuable ally to the safety man. He knows the temperaments of his newspaper men, knows what they will print and what they will reject, and often can construct a genuinely interesting article about this subject, usually considered as a dull subject. We must bear in mind that a newspaper prints only that which is news and will reject, unless paid for, that which is dull or that which plainly is business propaganda. The company publicity man has a further interest in helping this work. He is vitally interested in building up public good-will through his printed matter and, after all, this phase of accident prevention work to a large extent is public-relations work and company advertising. When occasionally the company's name is tied into educational work of a character calculated to aid public safety, the standing of the company is enhanced in the public's estimation.

The accident prevention man always has his prominent place in the company publication where he can preach a little to his own people in a very personal way. Bulletins are a form of constructive education. As a rule they are utilized for publicity within the personnel of the company organization. The use of bulletins has been covered thoroughly in another report of this committee. (Journal of Electricity, May 15, 1926, Page 411.)

Pamphlets and instruction books must have a special appeal if they are to be kept from the waste basket. This may seem not to apply to the outside worker whom we are trying to reach, but bear in mind that the time which he devotes to reading is limited and that he does not read studiously. Such a booklet must have the special appeal of interesting text and must be brief, to the point, clear and understandable. True, a sefety code may be forced on a man's attention by examinations or other means, but general reading matter can not be forced upon him. He may sit through a dry general lecture because he must, but he will not read the same platitudes and generalities in print.

Then there is the set talk or lecture. There may be either formal or informal and may be given within the organization or to some outside class or group. Talks should be used sparingly within the organization because 90 per cent of the men will not listen very long with close attention. Talks to outside groups serve the added purpose of either advertising the company or promoting its public relations.

Publicity Aims

Constructive publicity promotes the thought of safety and the teaching of first aid. It is of the type which popularized the "Safety First" slogan in the effort to get everyone into the habit of taking first thought for personal safety. If the habit of safety can be built up, it will be by the use of this kind of education. Wide-spread knowledge of first aid can be furthered by publicity. It is absolutely true that one of the best ways to teach a person to avoid accident is to teach him what to do when that accident does occur. It brings home to him in an emphatic manner just what may be the consequences of carelessness. If a general knowledge of first aid to those shocked by electric current can be widely spread it will do much to minimize the results of such accidents. The success of resuscitation depends entirely upon the knowledge of the first man to reach the injured and this knowledge can be spread through publicity channels.

Informative publicity is the close adjunct of public relations, placing the correct story before the public. Often the account of some unfortunate circumstance is so written up that it creates a feeling of distrust toward the electric utility and its equipment. Happy is the company that has so qualified itself that reporters will come frist to the company representatives for their accounts and will print the true story without distortion.

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* Prepared for the accident prevention committee.

[2] **Executive Committee.**—J. G. Rollow, Los Angeles Gas & Electric Corporation, chairman. **C. F. Gilcrest,** San Joaquin Light & Power Corporation, vice-chairman. **J. W. Andree,** Southern California Edison Company. **J. M. Buswell,** San Joaquin Light & Power Corporation. **P. E. Chapman,** Pacific Gas and Electric Company. **L. J. Corbett,** Pacific Gas and Electric Company. **R. R. Cowles,** Pacific Gas and Electric Company. **E. J. Crawford,** San Joaquin Light & Power Corporation. **P. O. Crawford,** The California Oregon Power Company. **Walter Dreyer,** Pacific Gas and Electric Company. **W. R. Frampton,** Southern California Edison Company. **J. C. Gaylord,** Southern California Edison Company. **J. M. Gaylord,** Southern California Edison Company. **F. R. George,** Pacific Gas and Electric Company. **A. J. Hall,** Ontario Power Company. **R. H. Halpenny,** The Southern Sierras Power Company. **N. B. Hinson,** Southern California Edison Company. **R. A. Hopkins,** Westinghouse Electric & Manufacturing Company. **A. G. Jones,** General Electric Company. **R. G. Jones,** The Southern Sierras Power Company. **H. K. Kalb,** San Joaquin Light & Power Corporation. **H. A. Laidlaw,** Pacific Gas and Electric Company. **H. Michener,** Southern California Edison Company. **G. A. Riley,** Los Angeles Gas & Electric Corporation. **M. S. Slaughter,** The Southern Sierras Power Company. **T. W. Snell,** Coast Valleys Gas & Electric Company. **W. R. Van Bokkelen,** Coast Counties Gas & Electric Company. **C. W. Wiggins,** San Diego Consolidated Gas & Electric Company. **C. E. Young,** Pacific Gas and Electric Company.

[1] **M. S. Slaughter,** The Southern Sierras Power Company, chairman. **S. M. Bullis,** The California Oregon Power Company, vice-chairman. **Los Angeles Bureau of Power & Light:** W. L. Smith. **Los Angeles Gas & Electric Corporation:** P. F. Melnick, J. R. Rowe. **Pacific Gas and Electric Company:** S. C. Dickinson. **San Diego Consolidated Gas & Electric Company:** W. E. Richmond. **San Joaquin Light & Power Corporation:** J. M. Buswell. **Southern California Edison Company:** L. L. Dyer, C. S. Johann, D. G. Macey. **The Southern Sierras Power Company:** R. G. Jones. **Westinghouse Electric & Manufacturing Company:** P. B. Garrett.

Publicity which seeks to warn of hazards is well exemplified by the campaign for safety in automobile traffic. Much remains to be done in this direction. The danger to boys climbing trees through which wires run and education of the public to not depend upon the insulation quality of weather proofed wire are examples of what should be done. Without carrying the work to a point where the use of electricity will be discouraged or without embarrassing the electric utilities by enforced drastic regulation it is possible to educate the public as to how to treat live wires and apparatus.

A great deal of co-operation has come from insurance companies. They are spending great sums to spread the doctrine of safety knowing that it brings good returns in reduction of claims. The utility companies have this same reward to reap from money and effort spent in educational publicity in accident prevention. They have more to gain, for the reaction of the public to efforts to lessen injuries is a great force to better public relations. Economic necessity forces universal use of electric service; thus it is necessary to create universal trust and security.

The use of electrical appliances is growing constantly and its development will not be hindered by warning its users of hazards. By explaining proper operation and normal safeguards a confidence will be instilled into the minds of the users. It is not in the apparatus that the danger lies, but in the unskilled or ignorant use of that apparatus, or in the use of sub-standard apparatus.

In addition to the humanitarian aspect of accident prevention work there is the practical and inevitable money-saving result that justifies the expenditure. That is the reason why utility companies can well afford to carry it on. It is pleasant to be able to combine the two. When, through education a youth is taught to leave that wire alone, he is saved from injury and both a direct monetary loss and an impairment of public relations which must be overcome by cash expenditure are avoided.

If, when a man is rendered unconscious by electric shock, some one is there who has received a knowledge of first aid through educational publicity, then a genuine service has been rendered that will avoid human and financial loss.

Above all, publicity must be direct in its endeavor, must deal directly with how to be safe and specifically what to avoid. No longer can be delivered effectively general discourses on "be safe and you'll be happy."

To sum up, educational publicity no matter what form it takes must be compelling in its call for attention. It must carry a direct purpose, not an aimless exhortation to be good; must convey some brief and definite message of what to do. If it is made effective in this way it will sow seeds which will bring results to the utility companies in money saved, in advertising, and in better public relations.

Safe Practices in Substation Operation*

By L. L. DYER

Safe practices are divided into two fundamental branches: First, that pertaining to personnel and second, that pertaining to equipment.

It must be remembered also that anything proposed along the lines of safety and accident prevention must be considered both from a cold economic standpoint and from the humanitarian standpoint. It must be remembered also that points which may appear to the average individual as purely humanitarian may have a most decided bearing upon the cold, economic, dollars-and-cents side of the questoin. This is a point which too frequently is overlooked, particularly when safety measures are being discussed by a purely technical engineering group.

These few points are brought out first because it is necessary that they be kept in the foreground while making a study of accident prevention methods.

Dealing with the personnel side of the case it is an undisputed fact that men trained in safety methods and who really practice carefulness are worth far more than all the safety devices ever invented. By the same token it follows that a habitually careless personnel can nullify to a great extent all the safety measures put into effect. It is a fact, and psychologically correct, that if a group of men are inclined to be careless, these men become more and more careless as various safety devices are installed, relying entirely upon the various safety devices to protect them. Thus to a large extent protection is nullified as fast as it is installed. Consequently, effective accident prevention must start with the education of the personnel.

Careful Club

In the Southern California Edison Company there has been worked out a program which has as its purpose the education of the men in the field along lines of accident prevention. An organization has been formed that is known as the Careful Club, and there is an accident prevention committee that covers the whole organization. In the operating department, the assistant manager of operation is the chairman of the accident prevention committee. Each subdepartment head is a member of this committee, and makes written reports monthly.

Each committee member then forms Careful Clubs within his own organization. In the department of sub-station operation, for instance, the four division superintendents act as chairmen of field committees for their divisions. The members of field committees are the station chiefs, electricians, and any others who may be selected from time to time because of their excellent record in accident prevention activities.

All Careful Club field committee members are provided with a distinctive green and white button of appropriate design which they are required to wear conspicuously at all times while on the job and which is their badge of authority to interevene at any time when a question of safety is involved. It is standard practice to hold a station chiefs' meeting once every month. At this meeting the first order of business is allotted to Careful Club matters.

Any station chief or other Careful Club member who has been guilty of carelessness is punished by being deprived of his button for a period of time depending upon the seriousness of the case in question. The amount of time is determined by vote of field committee members present, the department head reserving the right of final judgment. So far, there has never been any occasion to change the verdict rendered by this committee. This practice has led to the Careful Club button being looked upon with respect and as a badge to be desired, causing men to become more careful themselves and to teach carefulness to those under their supervision.

A report on accident prevention, sickness, and mistakes in operation is turned in monthly to the division superintendent by each station chief together with safety suggestions from any of the crew. All such suggestions are briefly incorporated in a report of the division superintendent together with his comments. Practical suggestions are acted upon at once. All stations that have a record of six months without an accident causing loss of time, or a mistake causing interruption to service are given a plaque to be hung in the station as testimony of their carefulness as a crew. This plaque is an enlargement of the button, in enamel on sheet metal. Any accident or mistake deprives the station of the plaque until another six months' record is attained. This idea has proved of considerable value in stimulating interest in accident prevention work. It is psychologically correct, because it offers something definite for which the individual can work, a vital necessity when dealing with the average man who cannot and will not work purely for an ideal.

Another excellent practice is the holding of meetings at the various stations at which all men participate in a drill on artificial respiration and first aid. Such meetings are held weekly, presided over by division superintendent or station chief and last about 30 minutes.

Systematic Training

One of the most important things is to see that new men are given the proper safety and first aid instruction at the very beginning of their training. Often men who are old in the game of operating come into the organization. At first some are inclined to make light of safety instructions. They

* Prepared for the accident prevention committee.

are the "wise guys and full of oratory," but a short time at one of the training stations gives them a good square look at themselves and they soon "cut the loud stuff" and get down to business. The training station impresses the new man with the seriousness and importance of his work. Once his mental attitude is lined up and his ambition is directed along constructive channels he becomes an asset and is rewarded with a better job and more money.

A card record of every man is kept and in order to determine a man's ability a rating system has been devised by which each man is rated or graded every six months on ten points, one of which is carefulness. All promotions are based primarily upon these gradings. The record cards carry these gradings together with his mistakes, accidents, commendable acts, etc. Each man's card may be examined by the man any time he requests it. In the main, Edison men are ambitious and, knowing that carelessness on their part will result in low marks and retard promotion, the tendency to learn and practice safe methods is stimulated greatly. All new men and those who make an occasional mistake are given a card which has printed on it, "Accidents Must be Prevented. Educate or Eliminate the Careless Man."

It is the constant "pounding away" at it that brings results. Intensive safety first campaigns are beneficial only for a short time, although they may become necessary if carelessness is allowed to become too pronounced. It is the ceaseless methodical, everlasting, personally-conducted education and instruction of the individual that produces the best results. Continually "preaching," correcting the men for any little carelessness no matter how slight, and disciplining or eliminaitng those below par is the only way that has been found to be at all successful.

Wherever it is possible in medium-sized stations and always in large or complicated stations two men should always be present when doing any switching such as opening or closing disconnects or grounding switches. When these two men perform the operation the least experienced man should do the actual operating, the more experienced man checking him. This is suggested because if the more experienced man were to do the switching and were to make a mistake the younger man might hesitate about stopping him, being inclined to take it for granted that the more experienced man knows what he is doing. Where a switching order is given by the operator to an assistant operator to be performed in a remote part of the building or in an outdoor rack the order should be in writing. Assistant operators have been known to get a verbal order twisted or forget part of it with serious results. The Edison company uses a regular switching order form, easily and quickly filled out, which is given to the assistant operator who checks it upon receipt by reading it out loud to the operator before starting to execute the command.

Equipment

Taking up the mechanical side of the question, it is practically impossible to go into any great detail as to the various safety devices and practices in more or less general use. However, a few points that seem to be important will be touched upon.

It is a safe practice to provide some means for indicating a hot bus or line. Pilot lamps, volt meters, etc. are best. The cost of potential transformers runs into money, but their real value cannot be measured in actual dollars and cents for it must be remembered that if they prevent even one accident they have paid for themselves.

Grounding switches manually operated are very desirable. The Edison company paints its grounding switches red to distinguish them from service switches. Ground chains or cables are dangerous around stations, not only because they may be pulled into energized apparatus, but because they are of very little use except to bleed off static. Only a small amount of dynamic current will fuse them.

"Men at Work" signs or switch blocks should be used always when men are given a clearance to work on apparatus, bus or line and a note of such clearance made in the log book in red ink giving the name of the party in charge of the work and also the party giving clearance.

In designing stations, care should be used to allow sufficient clearances. Sometimes this is overlooked or sacrificed in the interest of economy. It is natural to keep first costs low, but it is necessary not to lose sight of the fact that first cost occurs only once, while operation and maintenace go on for the life of the station. Cramped quarters and small clearances make for slower and more dangerous work as well as a more nervous personnel and this increases maintenance cost and causes more accidents. The use of protective screens on outdoor racks has reduced materially the hazards there.

To reiterate, the best safety device is a careful man and carefulness is a matter of education.

Electrical Apparatus Committee Reports[1]

Relay and Relay Applications*

Following the program of past years the field of work covered by this sub-committee during 1926-27 included the following subjects:

1. New types of relays or variations in standard types put forth by manufacturers or developed by operating companies.
   - (a) For protection of lines.
   - (b) For protection of transformers and other equipment.
2. New or unusual applications or connections of relays and their auxiliary apparatus.
   - (a) For protection of lines.
   - (b) For protection of transformers and other equipment.
3. Reports of operating experience with relays and their auxiliary apparatus.
   - (a) Data and analysis as to number and correctness of operation, causes of failures, etc.
   - (b) Methods of determining relay applications and settings, use of system calculating boards, etc.

General practices of the companies on the Pacific Coast have been covered in recent previous reports of this sub-committee. Data included in this report is considered as new inasmuch as it has not been specifically included in such reports.

New Types of Relays

Under this subject the Westinghouse company calls attention to improvements in the CZ impedance-distance relay brought about by placing the directional

[1] **H. A. Laidlaw,** Pacific Gas and Electric Company, chairman. **R. H. Halpenny,** The Southern Sierras Power Company, vice-chairman. **Allis-Chalmers Manufacturing Company:** F. H. Searight. **The California Oregon Power Company:** R. S. Daniels, F. D. Emory. **Coast Counties Gas & Electric Company:** W. R. Van Bokkelen, A. E. Strong. **Coast Valleys Gas & Electric Company:** G. A. Peers, T. W. Snell. **Garland-Affolter Engineering Company:** P. H. Affolter. **General Electric Company:** J. H. Cunningham, H. E. Fuqua, W. E. Melarkey, M. H. Schnapp, W. C. Smith, J. S. Spurck, H. C. Stanley, E. E. Valk. **Great Western Power Company:** C. F. Benham. **Los Angeles Bureau of Power & Light:** J. C. Alberts, H. H. Cox. **Los Angeles Gas & Electric Corporation:** L. A. Buese, F. R. Knight. **Ontario Power Company:** A. J. Hall. **Pacific Electric Manufacturing Company:** E. Sixtus. **Pacific Gas and Electric Company:** N. P. Carlsen, Jr., B. D. Dexter, J. P. Jollyman, R. B. Kellogg, C. Kirtley, H. S. Lane, W. D. Skinner, H. T. Sutcliffe, R. W. Wilkins. **San Diego Consolidated Gas & Electric Company:** K. B. Ayres, E. D. Sherwin. **City of San Francisco Electrical Engineering Department:** P. J. Ost. **San Joaquin Light & Power Corporation:** R. C. Denhy, R. D. Likely, P. C. McCorkle, P. C. Oldershaw, E. K. Sadler, C. E. Schnell. **Southern California Edison Company:** L. H. Beebe, J. C. Gaylord, C. S. Johann, D. J. Kennelly, C. C. Long, H. L. Sampson, A. P. Sessions, E. R. Stauffacher, A. D. Irion. **The Southern Sierras Power Company:** F. B. Ayres, M. L. Baden, J. N. Keith, D. K. Lawson, P. H. Yelton. **H. B. Squires Company:** S. P. Russell. **Westinghouse Electric & Manufacturing Company:** J. E. Brown, A. W. Copley, W. F. Grimes, R. A. Hopkins, W. P. L'Hommedieu, R. C. Stackhouse, W. L. Winter.

* **Report of sub-committee.—H. S. Lane, chairman.** M. L. Baden, L. A. Buese, N. P. Carlsen, W. F. Grimes, A. D. Irion, P. C. McCorkle, J. S. Spurck.

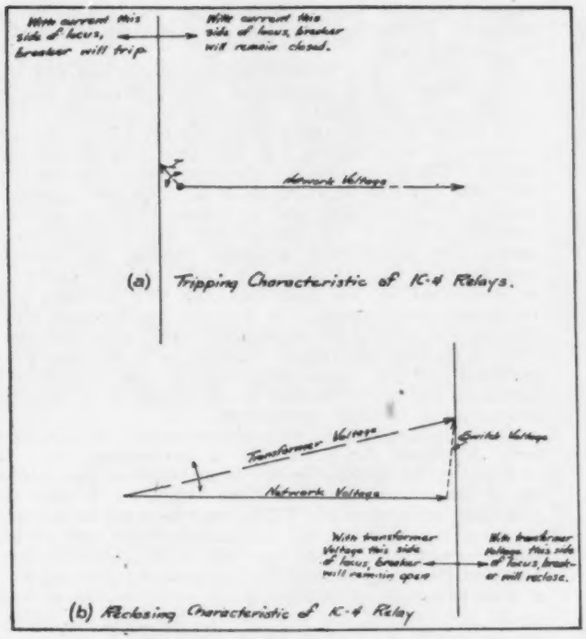

With current this side of bus, breaker will trip.
With current this side of bus, breaker will remain closed.
Network Voltage
(a) Tripping Characteristic of IC-4 Relays.
Transformer Voltage
Switch Voltage
Network Voltage
With transformer voltage this side of bus, breaker will remain open
With transformer voltage this side of bus, breaker will reclose.
(b) Reclosing Characteristic of IC-4 Relay

Fig 1. Characteristics of IC-4 relay.

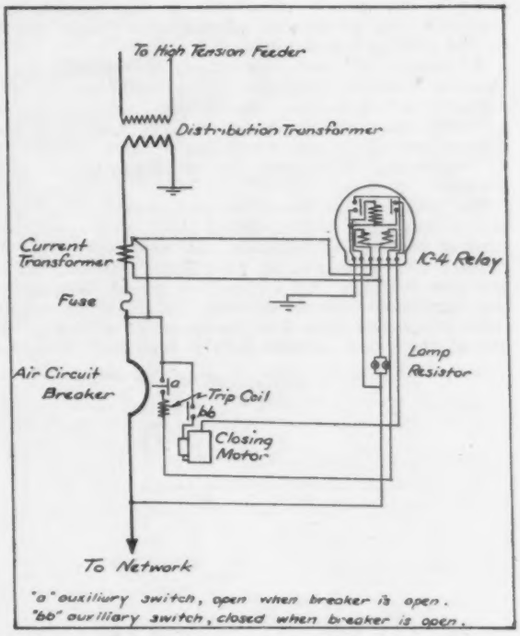


Fig. 2. External connections of single-element IC-4 relay.

element in series with the secondary and upper-pole winding of the impedance element electromagnet. The purpose of this arrangement is to make the relay inoperative except when the power flow is in the correct direction and to prevent incorrect operation due to surges or rushes of synchronizing power which may occur after a fault has been removed from the system. All three conditions for operation—high current, low voltage, and power flow in the correct direction—must occur simultaneously and must last sufficiently long to allow the relay to operate. This improvement necessitated considerable changes in the wiring of the relay and a re-design of the external resistor used with the relay.

Development of the KX and KY compensators also is reported by the Westinghouse Company. These compensators are intended to make possible the use of the low-tension bus as a source of CZ relay potential, at either generating stations or substations and with neutral grounded or ungrounded. The KX compensator is designed to compensate for transformer impedance drop in case of line-to-line faults. The KY compensator is intended to correct for shifting of ungrounded neutral in star-connected banks with phase-to-ground fault on the line.

The Southern California Edison Company reports testing the new CA ratio-differential relays for transformer protection in comparison with the customary differentially connected relay. In particular the point is raised that experience has indicated that in using auto-balancing transformers in such applications actual field tests resulted in connections to relay taps other than the theoretical taps indicated. The CA relays do not permit this field test and must be connected according to the theoretical taps. Further, it is stated that the minimum tripping value of the

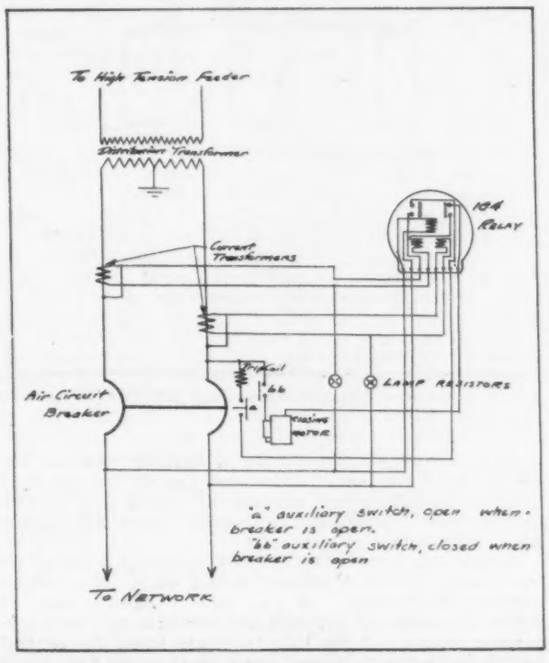


Fig. 3. External connections for single-phase, 3-wire IC-4 relay.

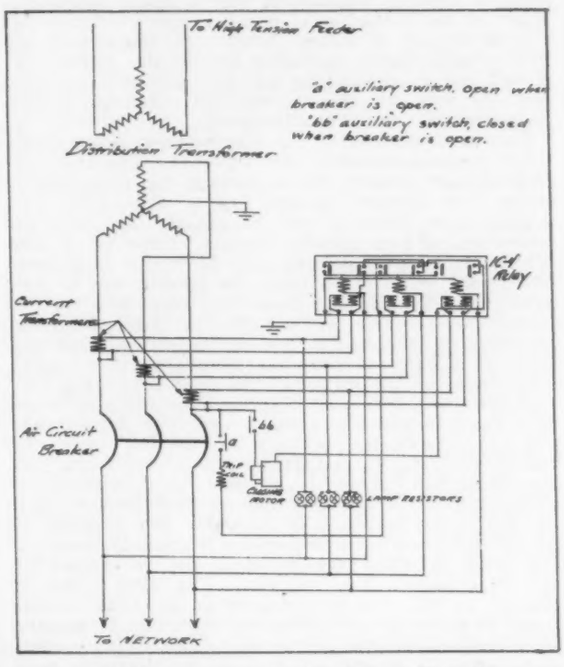


Fig. 4. External connections for 3-element IC-4 relay.

relay is not readily obtainable in the field unless a complete set of curves already has been obtained in the testing laboratory.

A number of developments are reported by the General Electric Company. In a modification of the 3-phase induction-type overcurrent relay (3 element IA-201) each single-phase element has a separate contact circuit for use where each phase of the circuit is separately protected by a single-phase circuit breaker.

The single-phase induction overcurrent relay IA-201 now is available in a modified form, with contacts for closing two circuits instead of only one. This new contact also is applicable to various current, voltage, and power relays. As a result of recent developments the induction overcurrent relay in its more sensitive form takes less than 3 volt-amp. at 60 cycles to operate at the rated current of the tap used. This small

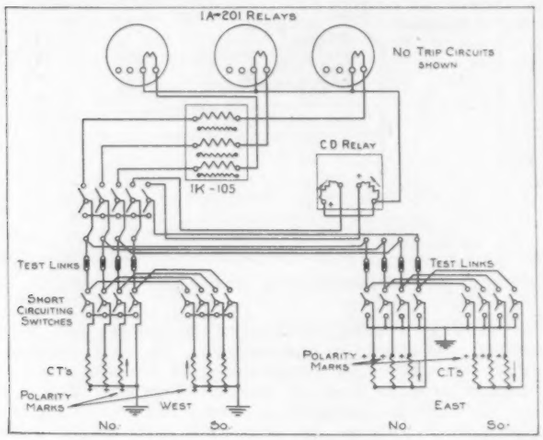


Fig. 5. Proposed scheme of parallel-line protection using type CD relay as a ground relay.

burden is of value when bushing current transformers are used.

The IJ-7 current-differential induction relay for protection of generators against internal faults has been standardized, a target has been added and a new type of silver contact installed. The percentage characteristic of this relay makes it possible to secure greater sensitivity while insuring against faulty action for shorts external to the machine. The same relay is used in conjunction with a power-directional relay for the protection of parallel lines which are unlike in respect to power factor. By connecting the IJ-7 relay with its operating coil in the differential circuit and its restraining coil to carry the load current the difficulty due to vectorial unbalance of the line currents largely is eliminated.

Two modifications of the single-phase power-directional overcurrent relays are reported. The IB-3 has single-throw contacts and is suitable for protecting a single line against ground faults. The IB-4 has double-throw contacts and is suitable for selective protection of two parallel feeders. Three relays for directional residual ground fault protection have been developed. In the IC-5 relay the current coil is supplied with the residual from the three-line current transformers. The coil on the potential magnetic structure is connected in one corner of the secondary delta of a bank of potential transformers connected Y-grounded on the primary, providing circulating current always in the same direction upon the occurrence of a fault to ground. Current and time adjustments are made as in the ordinary overcurrent relay. In the IC-5Y1 relay the application is the same but the directional current is supplied by a current coil in the neutral of the generator or transformer bank. In the more unusual case where the neutral is grounded through a resistor, application is made of the relay in which the potential coil is excited by the drop across the resistor. The IB-5 relay is similar to the IC-5Y1 except that no time adjustment is provided. The time of operation is secured by a standard IA-205 overcurrent relay. This enables two rleays to be graded in time satisfactorily with respect to each other. This relay has double-throw contacts, permitting its use for selective protection of parallel lines.

Two of the new induction-type relays are for use in synchronizing in connection with automatic station equipments, particularly reclosing equipments. The IJ-9 relay controls the closing circuit of the circuit breaker at synchonism. It has two differential elements. The instantaneous element permits connecting the two circuits together only if they are approximately in phase and the retarding element permits connection only if the frequencies are approximately equal. The IJ-10 relay prevents closing the breaker except when the systems are tied together elswhere as evidenced by the fact that the two voltages are in phase continuously. It has two split-phase electromagnets acting in opposition upon a single disc. The restraining magnet is excited by a voltage proportional to the vector-difference of the two circuit voltages, the other magnet is energized by a voltage proportional to their vector-sum.

A new induction-type temperature relay, TRA-A, has been developed for protection of generators, etc. It is designed to operate in the Wheatstone-bridge hookup of the standard temperature indicator. A new alternating current relay, TRW, may be used as a master starting element, as an undervoltage, or as an undercurrent device. It has one circuit-opening and one circuit-closing contact for independent circuits, has a wide range of calibration, picks up at values as low as 10 per cent of the coil rating, and may be either instantaneous or time-delay in operation.

The differential-frequency relay IJ-4 is a new device which is used with automatically controlled synchronous motor-generator sets. It has two induction discs on a common shaft and two coils associated with each disc. It can be adjusted so that the opposing torques are balanced at a predetermined frequency. An increase of frequency will rotate the disc in one direction, a decrease in the opposite. When used with

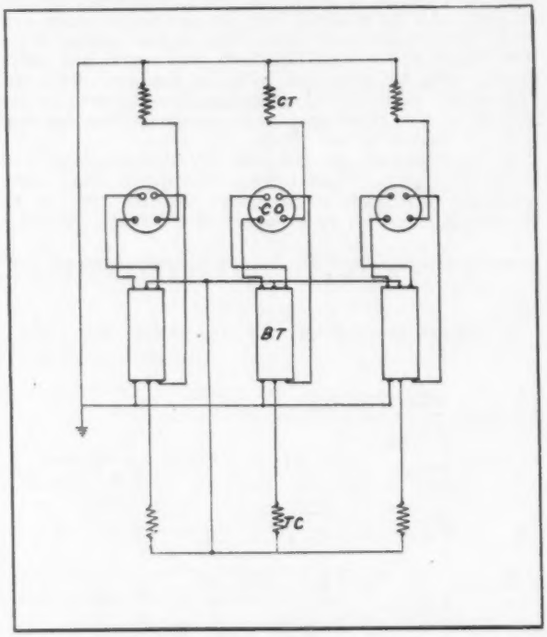


Fig. 6. Connections for combined overload and type BT transfer relay.

such motor-generator sets on a lighting system, the relay opens the motor field and lowers the d.c load when a predetermined amount of motor slip occurs, and restores conditions to normal when the motor again falls into step.

A new trip-free relay, PB-Y7, prevents holding an elecrtically operated breaker closed while an overload current is flowing. It has two windings, one of which is energized through the contacts on the overcurrent relays. If the latter operate when the control switch is in the "closing" position the trip-free relay

picks up and is sealed in, preventing reclosure of the breaker until the control switch is pulled for "opening."

A new development in distribution is the a.c. network system. It consists of a low-tension network with the mains interconnected and fed through automatic switches from a number of distribution transformers energized by a number of high-tension feeders so that the loss of any feeder will not shut down the network. The protection of the system requires means for isolating defective parts of the high-tension system. Low-voltage faults are allowed to burn clear. In addition, it is desirable to disconnect transformers from the network when their feeder is de-energized, closing the switch again when the feeder again is energized.

The relay IC-4 provided to meet these conditions operates to trip the low-tension switch when current flows from the network to the transformer and to reclose the switch when the voltage conditions are

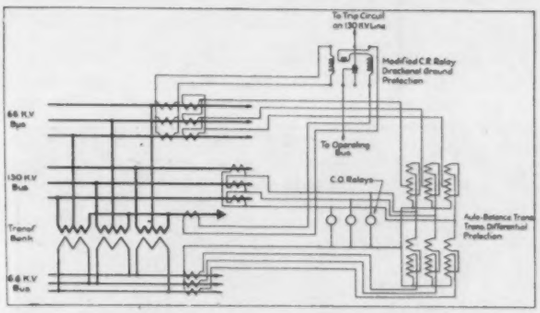


Fig. 7. Differential and directional-ground relay application.

such as to cause power to flow into the network. The potential coil of the relay is connected across the network and the current coil is so connected as to be energized in accordance with the load current with the switch closed and energized with the voltage across the switch with the switch open.

Figs. 1 to 4 inclusive illustrate the application of this relay.

New Applications of Relays

Under this subject a number of interesting applications have been reported.

The Southern California Edison Company submits a diagram showing the application of a CD selective-differential current relay, as a ground relay, in conjunction with IA-201 overcurrent and IK-105 power-directional relays. This connection allows any slight difference between the ground currents to operate the CD relay and trip the breaker directly. The tripping contacts of the IK and IA relays are in series, the latter controlling the time of breaker operation. See Fig. 5.

The Pacific Gas and Electric Company reports the installation of the revised BT transfer relay in connection wtih CO overcurrent relays for tripping a breaker by means of the line current. The closing of the contacts of the CO relay operates the transfer relay thereby cutting the breaker trip coil directly into the current transformer circuit. Experience with this installation indicates that the uncertainty of operation of the old type BT relay has been satisfactorily overcome in the new relay. See Fig. 6.

The same company reports the application of a CV voltage relay to a special problem in connection with the Pit-Vaca 220 kv. system which comprises the Pit No. 1 and Pit No. 3 plants, the substation at Shasta tying in with the California-Oregon Power Company system, the terminal substation at Vaca-Dixon, and the two 220-kv. lines. Originally CV relays were installed to protect the banks at the plants and at the substations. It was found that trouble that resulted in dropping a large block of load frequently caused high voltage which separated the entire Pit system. One additional CV relay was installed at each point, energized from either of two bank potentials, and with switch for transferring the tripping circuit to either line at will. The bank relays are set at about 20 per cent over voltage and the new line relays at about 15 per cent overvoltage. Thus upon the occurrence of such high voltage the selected line is dropped out first and the consequent drop in voltage on the remaining line results in holding the balance of the Pit system in. This installation has operated with entire satisfaction.

The California Oregon Power Company reports an interesting special installation of relays in the Copco No. 2 plant, where there are two 15,000-kva. 6.6-kv. generators and a single 30,000-kva. bank of transformers 6.6-kv. delta to 132-kv. star grounded with 66-kv. taps. The bank is protected by CO relays connected for differential operation through auto-balancing transformers to current transformers in all three windings. The lines are protected by overcurrent relays and by a directional ground relay, a CR relay modified for this special application. Fig. 7 shows the arrangement of equipment.

Reports of Operating Experience

Under subject 3a, data and analysis as to number and correctness of operation, causes of failure, etc., two reports were received.

The Southern California Edison Company submits the following analysis of failures and unnecessary relay operations during 1926 on all circuits from 11-kv. to 220-kv., inclusive:

Unexplained operation of CR relay	11
Incorrect type relays installed	11
Improper relay setting	8
Unexplained operation of CD relay	6
Failure of CO relay	5
Insufficient time selectivity on reclosure	5
CO relay grounded	4
Faulty secondary wiring	3
Unexplained operation of CO relay	1
Unexplained operation of differential relay	1
Potential transformer fuse blown on CR relay	1
Improper relay action	1
Wrong CR operation due to grounded station bank	1
Directional relays in service as overloads	1
Balance relays in service on 1-line operation	1

The Pacific Gas and Electric Company submits an analysis of relay operation on its 220-kv., 110-kv., and 60-kv. transmission network, covering the period 1923 to 1926 inclusive, that indicates a high percentage of satisfactory operation. The somewhat special practices of this company have been developed as the result of a number of years' experience in the operation of its large network, and are set forth in detail in the report of this subcommittee for 1924-25. (See page 477, Journal of Electricity, June 1, 1925.)

TABLE 1

Analysis of Relay Operations on the 220 KV, 110 KV, and 60 KV Transmission Network of the Pacific Gas and Electric Company

Year	1	2		3		4		5		6		7	
	Total Operations Involving Relays	Correct Relay Operations		* Relay Failures Due to Relay		Due to External Causes		Incorrect Relay Operations Due to Relay		Due to External Causes		Questionable Relay Operations	
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
1923	1593	1490	93.6	24	1.5	*	*	11	0.7	40	2.5	28	1.7
1924	1884	1699	90.2	31	1.6	*	*	3	0.2	108	5.7	43	2.3
1925	1865	1696	90.9	0	0.0	7	0.4	7	0.4	104	5.6	51	2.7
1926	1939	1728	89.2	1	0.0	16	0.8	11	0.6	147	7.6	36	1.8

* See explanation of analysis, Cols 3 and 4

Per centages refer to total in Col 1

The information in this report, shown in Table I, and the manner of its compilation would seem to be of practical interest. Consequently the explanation of the analysis is given in full below:

Col. 1. Total Operations Involving Relays.—All cases of trouble on the system which investigation showed involved the relays in service. This comprises the total of the other columns. (Relay operations due to accidental shorting or closing of contacts are not included in this tabulation.)

Col. 2. Correct Relay Operations.—All relay operations which have been proved to be correct under the conditions existing at the time. This includes many cases that were not entirely satisfactory from an operating standpoint, but where, owing to load, voltage, and power-factor conditions, it was necessary to credit the relays with correct operation, considering their connections and settings. There also are included here a number of cases where unsatisfactory relay operation occurred due to inadequate equipment. (See also Cols. 5 and 6.) In all cases, however, the relays themselves functioned correctly considering the circumstances.

Col. 3. Relay Failures Due to Relay.—All cases where subsequent investigation proved that conditions at the point in question were such as to permit correct relay operation, but where the relays themselves failed to function and the switch did not operate. Prior to 1925 investigations were not conducted with the same thoroughness and experience as in more recent years. In many cases failure

of the switch to operate was charged to the relays when under the present methods of investigation it would have been shown that the load or other system conditions at the time of the trouble did not call for operation of the relays, considering their time and current settings; or, that the failure was due to other external causes such as faults in wiring or auxiliaries.

Col. 4. Relay Failures Due to External Causes.—All cases of failure of switch to operate where subsequent investigation proved the failure to be due to break, ground, or other fault in the wiring, auxiliaries, or otherwise external to the relays themselves, or to power factor or other system conditions. Prior to 1925 these cases were not included in the tabulation.

Col. 5. Incorrect Relay Operations Due to Relay.—All cases of switch operation that have been proved by subsequent investigation and test to be due to faults, either mechanical or electrical, in the relays themselves. (This does not include relay operations which apparently were faulty because of inadequate equipment or improper connections.

Col. 6. Incorrect Relay Operations Due to External Causes.—All cases of switch operation which subsequent investigation showed to be the result of faults or improper connections in auxiliary apparatus external to the relays themselves, or to power factor or other conditions on the system.

Col. 7. Questionable Relay Operations.—All switch operations impossible to classify under Col. 2, 5 or 6. In most cases the operation has been unsatisfactory, but owing to lack of evidence it was considered unfair to classify it as incorrect, particularly as a test made after the trouble showed the relays to be operating correctly so far as could be determined.

Obviously every case of trouble on a network such as the one here under discussion involves a number of installations successively distant from the fault. The proper selection as to the load or time, whereby the more remote installations correctly function, is not included in this tabulation. The slight decrease in percentage of correct operations in the later years is attributed primarily to the increased accuracy and thoroughness with which the investigations have been conducted, as well as to the considerable increase in the number of relay installations involved.

It would seem that reports of experience with relay protective schemes upon some such agreed basis of analysis should be of material practical interest to member companies, and this is suggested as a proper subject for the attention of future subcommittees.

Under subject 3-b, methods of determining relay settings, etc., the Southern California Edison Company submits a report covering comparative laboratory tests of IA and CD relays. Results indicate that the latter is more dependable where very short time delays at high loads are desired. The Los Angeles Gas & Electric Corporation report the completion of a system-calculating board with which a systematic check of that company's relay system is under way.

The Bureau of Power & Light of the City of Los Angeles submits a report covering operating methods, routine, and experiences, which is summarized herewith:

Frequency of Tests.—Relays at power plants and central receiving stations are given primary and secondary tests every three months. Relays on distribution lines are given primary and secondary tests every six months, on feeder circuits a secondary test annually. After every relay operation (on trouble) relays are inspected, but are not necessarily tested unless faulty operation has occurred.

Organization.—The protection engineer has charge of relay protection schemes, the setting of relays and determining of transformer ratios, relay records, short-circuit calculations, and the supervision of special tests and experiments. The test department handles laboratory tests, special tests and experiments, installation and routine field tests.

Routing.—All relays are given a laboratory test, including check of factory specifications, insulation test, and thorough inspection of wiring, connections, and contacts. When placed in service the relay is given a primary installation test, and then tested at regular intervals as noted above.

Records.—Each relay is given a "record" number and records covering operations and tests are kept on appropriate forms.

In addition to the matter of analysis of operating experience mentioned above, this subcommittee recommends for consideration by future committees a study of operating methods, organization, routine, testing, and records of the various operating member companies, including a consideration of the relation of the meter committee to the subject of relays in view of the fact that relay testing in many companies is a function of the same department that handles meters.

Transformers and Regulators*

Probably the feature of ratio adjustments in connection with power transformer installations is occupying more attention today than any other item concerned in the actual operation of transformers. Certainly from the operator's viewpoint there is hardly anything more welcome and useful than the devices for changing taps by outside manipulation, and under certain conditions without even interrupting the load. Entirely practical and decidedly economical, these devices provide a means of making those voltage adjustments easily and as often as necessary and wherever desirable to divide properly the wattless current and give the required regulation incident to good service.

As best evidence of the popular demand for ratio adjusters in power transformers, all of the principal manufacturers of such transformers now are incorporating these devices in their transformers. Publication No. 256-69, N.E.L.A., is a report of the national apparatus committee on transformer tap-changing equipments. Therein are statements of some eight manufacturers accompanied by cuts and diagrams. For lack of space here, reference only is made to that report recommending it as a concise outline of the available methods and equipment so far devised for tap changing.

The San Joaquin system is fairly well representative of individual system practice in this regard. In

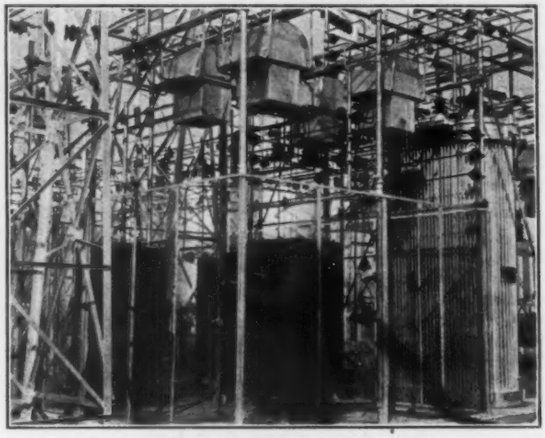


Fig. 1. Three-phase regulating transformer installation, San Joaquin Light & Power Corporation.

the past two years that company has installed 38 such power transformers totaling 134,750 kva. out of a total installed capacity of 539,400 kva., including spares. In general the adjustments on the high-voltage side allow for a total change of 10 per cent, those on the low side from 5 to 8 per cent. Experience with tap-changing devices on the above-mentioned system has been entirely satisfactory, although the necessity for operating them has been pretty well limited to seasonal changes, twice a year. Owing to the interconnecting distribution network between substations it seldom is necessary to interrupt the load at any substation to change taps. The load simply is carried by adjacent substations.

This same corporation has on order four single-phase, OISC, 3,000-kva 69.5/13.68-kv. transformers each with two 2½ per cent primary taps and eight 2½ per cent secondary taps. There will be ratio adjusters for both windings; however, only on the secondary are arrangements being made for changing taps under load. This will be the first installation of the sort and probably unique in that the tap changes will be actuated automatically by a contact-making voltage device. While this will be the first installation on the San Joaquin system where tap changing under load inherently is part of the transformers themselves, there are three installations where step-by-step regulator trasnformers or boosters have been applied, as an expedient, at those 110/69/11-kv. substations where the distribution bus voltage no longer could be raised to the desired value otherwise.

These are in the nature of 650-kva. in 3-phase, 13.2/11.5-kv. Y autotransformers with their auxiliary devices, comprising three reactors and six oil switches, per installation. One of these installations is shown

* **Report of subcommittee.—R. C. Denny, chairman.** P. H. Affolter, K. B. Ayres, L. H. Beebe, C. F. Benham, L. A. Buese, A. W. Copley, R. S. Daniels, R. C. Denny, B. D. Dexter, J. N. Keithe, P J. Ost, G. A. Peers, E. K. Sadler, H. Searight, W. C. Smith O. W. Wingard.

in Fig. 1 where the equipment as mentioned above may be singled out with the aid of the wiring diagram, Fig. 2, in which the apparatus bears the same relative location. The oil switches A, B, C and D are provided with suitable interlocking facilities so that the proper sequence of operation is followed out. The distribution bus may be boosted 15 per cent in six steps in accordance with Table I.

TABLE I—Regulation of bus voltage.

Position 1—A	closed, no boost	11,500 volts
Position 2—A&C	closed, ½ step	11,783 volts
Position 3—C	closed, 1 step	12,066 volts
Position 4—C&B	closed, 1½ step	12,349 volts
Position 5—B	closed, 2 step	12,633 volts
Position 6—B&D	closed, 2½ step	12,916 volts
Position 7—D	closed, 3 step	13,200 volts

Considering the 3-phase capacity that is regulated, 5,000-kva., and the ground space occupied, 12x18 ft., these installations probably are the most economical that could be devised for the purpose.

The Pacific Gas and Electric Company has a booster installation at Newark substation where the 11-kv.-load is carried by two 7,500-kva. banks, 100/11-kv., connected star-star and fed from the main 100-kv. bus through a common oil switch. By the use of a 250-kva., single-phase regulating transformer for each main power transformer, 20 per cent regulation is obtained, 10 per cent buck and boost. It is the general practice of that company to use regulator heads in connection with regulating transformers on the feeder buses of high-tension substations. By means of a control cabinet and shafting, automatic operation of the heads is obtained. This type of regulation is quite satisfactory for rural loads, but of course does not provide individual circuit voltage adjustment. Fig. 3 shows the layout at this substation.

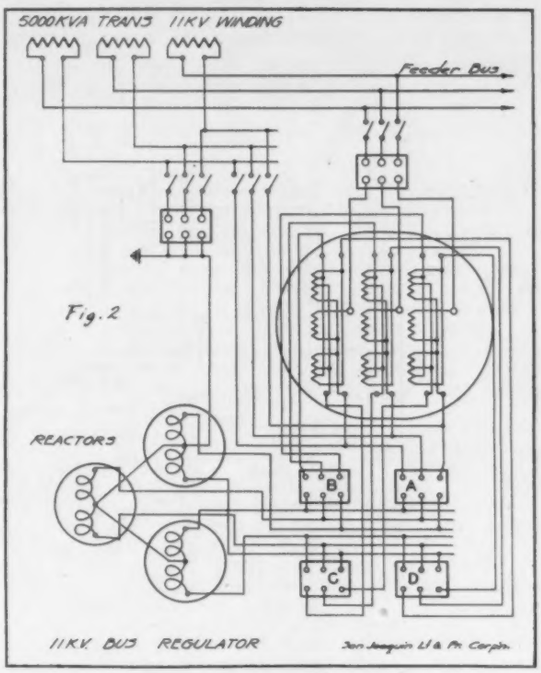


Fig. 2. Regulator for 11-kv. bus, San Joaquin Light & Power Corporation.

In connection with the operation of the regulator head, it is necessary to make use of a resistance in changing from one step to another. Cast iron was the material formerly used for this purpose, but to that material there was the objection that in the larger transformer installations the space and cost of iron resistors became prohibitive, particularly when it was necessary to use a resistance sufficiently large that it may be kept in the circuit continuously if the controller cabinet or drive shaft should fail, and permit the regulator-head fingers to stop between contacts. To overcome this difficulty, Globar resistance rods have been used and results have been entirely satisfactory. These rods are rated at 60 amp. and six rods are used with each regulator head.

The California Oregon Power Company reports an interesting and useful booster bank with switching arrangements at Grants Pass substation. A bank of three 50-kva., 2.2-kv. distribution-type transformers are connected to give a 10 per cent boost on a 2.2-kv. circuit. The entire arrangement is shown in Fig 4. The resistance shown in series with switch 3 consists of carbon rods. The sequence of operation is as follows:

To Cut in Service	To Cut Out of Service
1—Close Switch 3	1—Close Switch 3
2—Open Switch 1	2—Open Switch 2
3—Close Switch 2	3—Close Switch 1
4—Open Switch 3	4—Open Switch 3

These boosters have been cut in and out daily for two years during the irrigation season, well demonstrating the usefulness of such a scheme.

Ratio adjusters are particularly desirable in conservator-type transformers where otherwise much oil has to be handled to get at the terminals. However, the adjuster itself may lead to difficulties. The City of San Francisco reports an instance of an oil leak around the shaft of a tap changer in transformers of the conservator type. In that case it was impossible to change the packing because the hand wheel was so low that it would not permit raising the packing nut high enough to work with the packing. As the hand wheel was not designed to be removable it became necessary to modify the design, putting in a new shaft with a different arrangement of the hand wheel.

Service to electric furnaces does not appear to be concerning the companies of the P.C.E.A. very much. Transformers for this class of service are quite special and usually are specified by the furnace manufacturer, if not furnished by them. The Bureau of Power & Light of Los Angeles requires such transformer installations to have a total reactance of approximately 25 per cent, part of which may be inherent and the rest external to the transformers. Also it requires an automatic circuit breaker on the high-tension side of the bank. The Southern Sierras Power Company reports a 2-ton, 3-phase furnace installation on a 33-kv. line fed by three 250-kva. transformers having an inherent reactance of from 4 to 6 per cent. A 3-phase, air-core reactor with an effective reactance of 22 per cent brings the total to approximately 28 per cent.

A survey of the high-tension fuse situation among the companies of the P.C.E.A. reveals a number of companies that are using a few banks of transformers, fused on the high-voltage side as a means of protection, on lines up to 90 kv. Very likely the California-Oregon Power Company and the Southern Sierras Power Company have gone into fused transformer installation more extensively than others, having 3,000 and 2,000-kva. banks respectively as a maximum. Both report entirely satisfactory operation. All of the companies agree that this practice is successful only when the fuses are mainly for protection against transformer failure or bus shorts, and fused accordingly. None of the companies seem to have adopted any standards as to size and voltage of transformers to be fused, but there have been no banks larger than 3,000-kva. reported as fused. Probably the size of the system or short-circuit-current capacity at the point of installation should have as much to do with the practice as would the size of the bank itself. The Bureau of Power & Light is against the practice from the safety standpoint as well as because of the delay in restoring service.

The Southern California Edison Company mentions some difficulty with short circuits in the magnetic circuit of large power transformers. It is believed that these could be avoided by improvement in design. The San Joaquin Light & Power Corporation experienced some trouble of this sort in a bank some years ago. A year ago, upon opening up one of the transformers for electrical repairs, it was found that at some time a contact between a bolt and laminations had burned itself clear. Such troubles sometimes manifest themselves by noises or variations in the ammeter readings and affected transformers have been switched out of service before the trouble extended to the windings. It pays to investigate such indications. This sort of trouble seldom is likely to

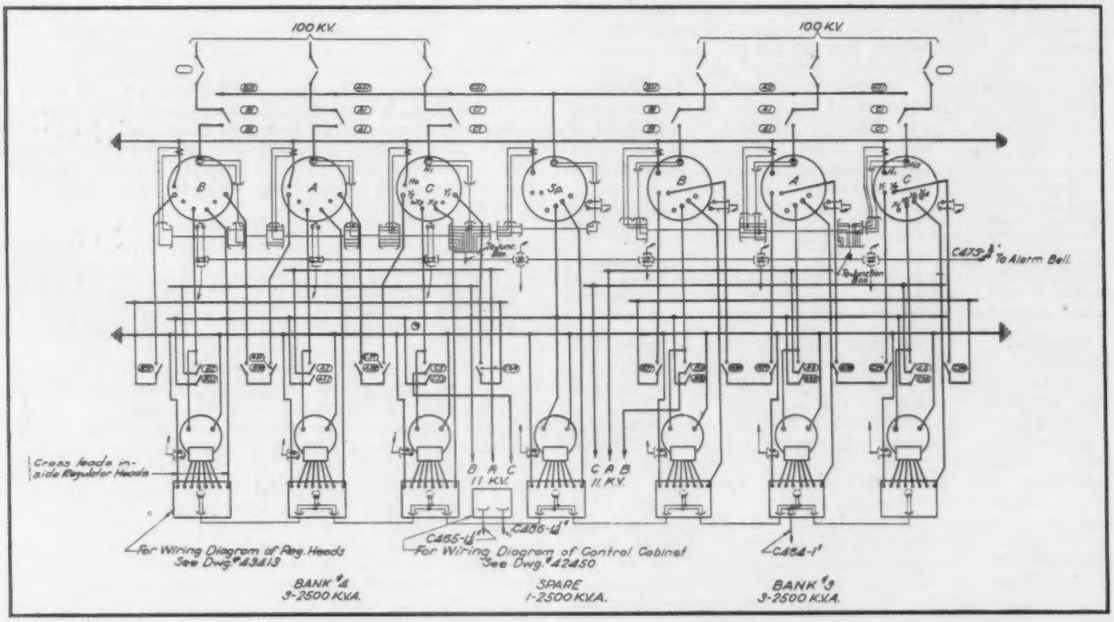

100 KV.
100 KV.
To Alarm Bell
Cross leads inside Regulator Heads
For Wiring Diagram of Reg. Heads See Dwg.# 43413
B A C 11 KV.
C A B 11 KV.
For Wiring Diagram of Control Cabinet See Dwg.# 42450
BANK #2 3-2500 KVA.
SPARE 1-2500 KVA.
BANK #3 3-2500 KVA.

Fig 3. Voltage regulating banks, Pacific Gas and Electric Company.

occur in modern power transformers where the core bolts are insulated with bakelite-impregnated asbestos moulded under heavy pressure.

Practically all of the companies prefer to use self-cooled transformers wherever practicable. The Southern California Edison Company has been converting water-cooled transformers to the self-cooled type by attaching new radiators to the old transformers. Heat runs on the rebuilt units have proved that good results can be attained. When water-cooled transformers are used the open circulating system seems to be preferred, using towers as the usual means of cooling the water. Some trouble has been experienced with flow indicators in closed circulating systems. The Bureau of Power & Light reports the installation of two sets of water re-coolers sold under the name of "Spray Towers." This tower consists of a sheet-iron housing which contains a small water reservoir of approximately 15-gal. capacity and a system of spray nozzles. A motor-driven pump circulates the water and a fan mounted on the end of the pump shaft sets up a draft in the tower. The cooler is used on a closed piping system and has a capacity of 75 gal. per min. with a temperature reduction of 25 deg. from 100 to 75 deg.

Several companies have transformer banks where a combination of self-cooling and forced air-cooling is used. The 90,000-kva. bank at the Great Western Power Company's Wilson substation probably is as recent and as large an example of combination cooling as can be found. That bank, when carrying loads up to 51,000 kva. operates as any ordinary oil-insulated self-cooled bank. Above that load, and depending upon the heating, a blower may be used to operate air jets along the radiating surface. The blower is driven by a 50-hp. induction motor and delivers air at the rate of 8,000 cu. ft. per min. at a pressure of 4 oz. to an air chamber provided around the base of each transformer. From there it passes upward through small distribution pipes so placed as to impinge the air in small jets against the surface of the radiators. The air leaves these pipes at a fairly high velocity, scours the surfaces of the radiator, removes the dead air film next to the radiating surface, and at the same time induces additional general circulation of air around the radiators. The piping arrangement for the forced air cooling is shown clearly in Fig. 5.

Transformers of the Wilson bank are provided with ratio adjusters on both the 220 and 125-kv. windings, the former controlling three 5 per cent taps and the latter five 4 per cent taps. Tap changes are not made under load. However, there is not the necessity for frequent changes as the voltage, once adjusted for seasonal operation, can be maintained quite well by the synchronous condenser at that station. Also, there is embodied in those transformers the latest and approved ideas of insulation in high-voltage trans-

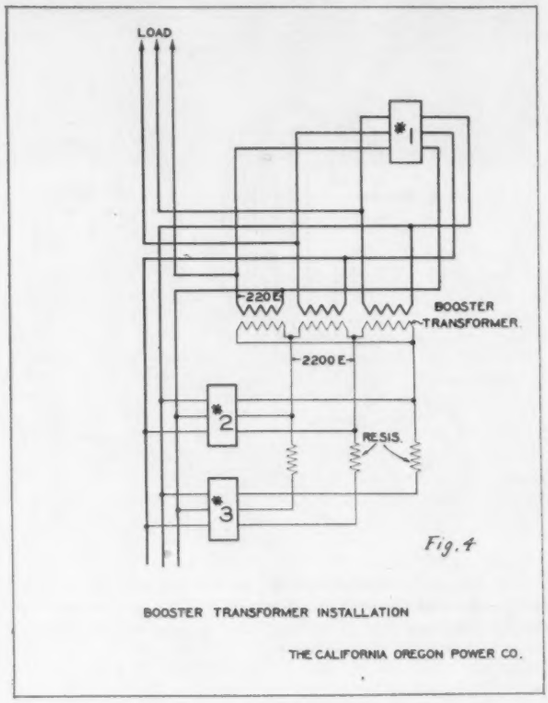


Fig. 4. Booster transformer installation, California Oregon Power Company.

former design. Every precaution was taken to insure safe operation. Insulation of the end turns of the high-voltage winding is especially heavily reinforced and is graded from the line-end down to the main sections which are insulated uniformly for many times the normal stress between turns. Use also is made of a static plate or shield connected directly to the conductor of the coil to reduce stress between end coils and end turns that would result from surges due to switching, lighting, etc.

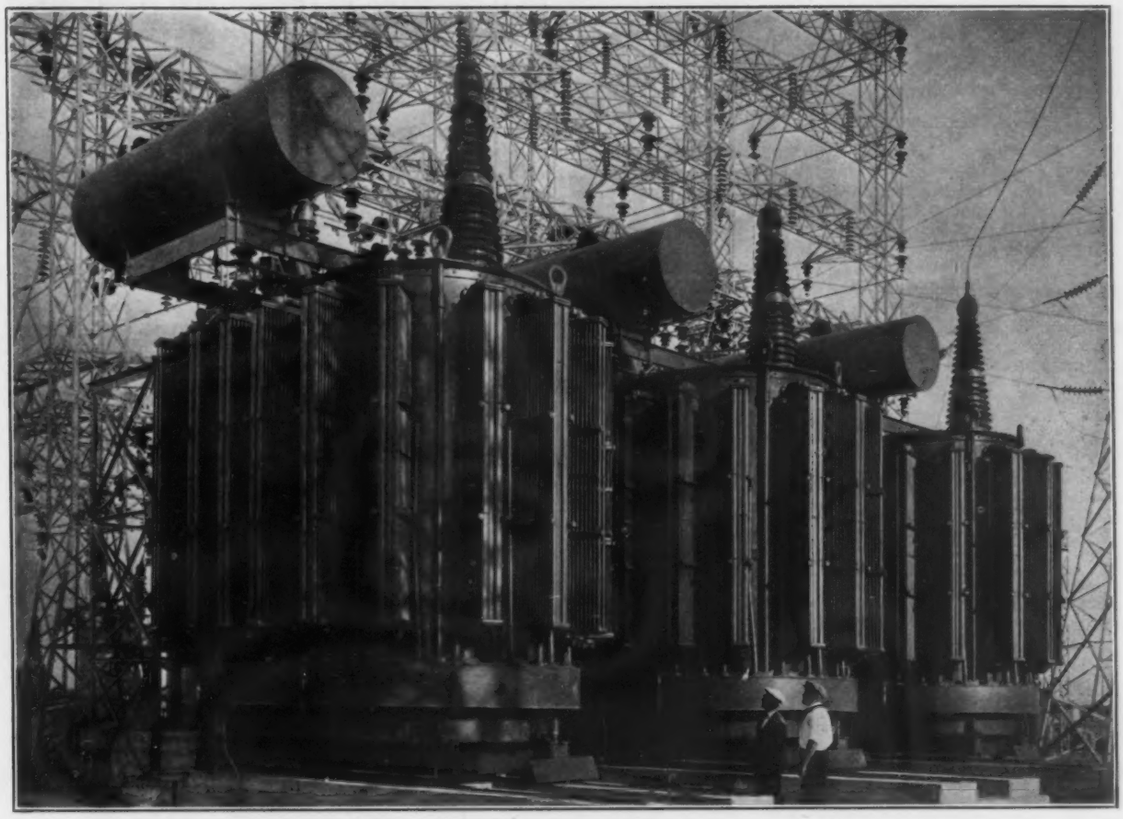


Fig. 5. Air pipes and header arranged for forced air cooling, 90,000-kva. bank, Great Western Power Company.

The wisdom of such methods was demonstrated on the system of the San Joaquin Light & Power Corporation during the summer of 1926. A number of 5,000-kva., 110/69/11-kv. auto-transformers, insulated similarly to the ones just described, withstood lightning discharges when others operating under the same conditions were burned out. Other features of design receiving much attention have been the arrangement of the tapped coils to maintain a balanced magnetic condition against short-circuit forces. Methods of blocking and bracing of coil also have shown improvement.

In all this the electrical efficiency has not been lost sight of, but constantly has improved to almost unbelievable values. In this regard there may be cited the 33,000-kva. water-cooled bank at Balch power house of the San Joaquin Light & Power Corporation, one of the most recent to go into service on the Pacific Coast. Test figures show 98.55 per cent efficiency for quarter load, 99.07 per cent for half load, 99.14 per cent for three-quarter load, and 99.11 per cent for full load. In short, it appears that the present-day transformer has become as reliable, flexible and effecient as the electric generator itself and now is a weak link in the chain.

At the Midway steam plant of the San Joaquin Light & Power Corporation there is a 3,000-kva. distribution bank which also serves to correct phase relations to permit the station bus to be paralleled with other adjacent substations. Owing to the fact that the voltage of the generator bus is subject to frequent changes to meet system conditions, it is necessary to regulate the 11-kv. distribution bus. This is accomplished by means of a 3-phase 500-kva., 11.5-kv. induction regulator giving 1,150 volts boost or buck. The reactance of the transformer bank itself affords sufficient protection for the regulator, hence reactors are not used. This installation has been useful and satisfactory.

Another regulator installation on the same system and perhaps a little more out of the ordinary is that at the Lompoc substation where a 69/11-kv. star-star bank of 1500-kva. capacity is located at the end of a transmission line. The nature of the Lompoc load necessitates close voltage regulation. It was decided, therefore, to regulate the 11.5-kv. bus. Two 69-kva., single-phase, 2.3-kv. induction regulators were used, giving 10-20 per cent buck or boost. Suitable current and potential transformers were used to adapt the regulators to the higher-voltage circuit. This installation has given satisfactory service. The wiring diagram of this installation, Fig. 6, is self explanatory.

Regulation of individual 3-phase distribution circuits in rural districts is not indulged in extensively among P.C.E.A. companies. It is realized, however, that the electric-range load in rural communities sooner or later may require regulation of such circuits. Most of the companies have a few scattered cases of this sort and are meeting the problem in various ways.

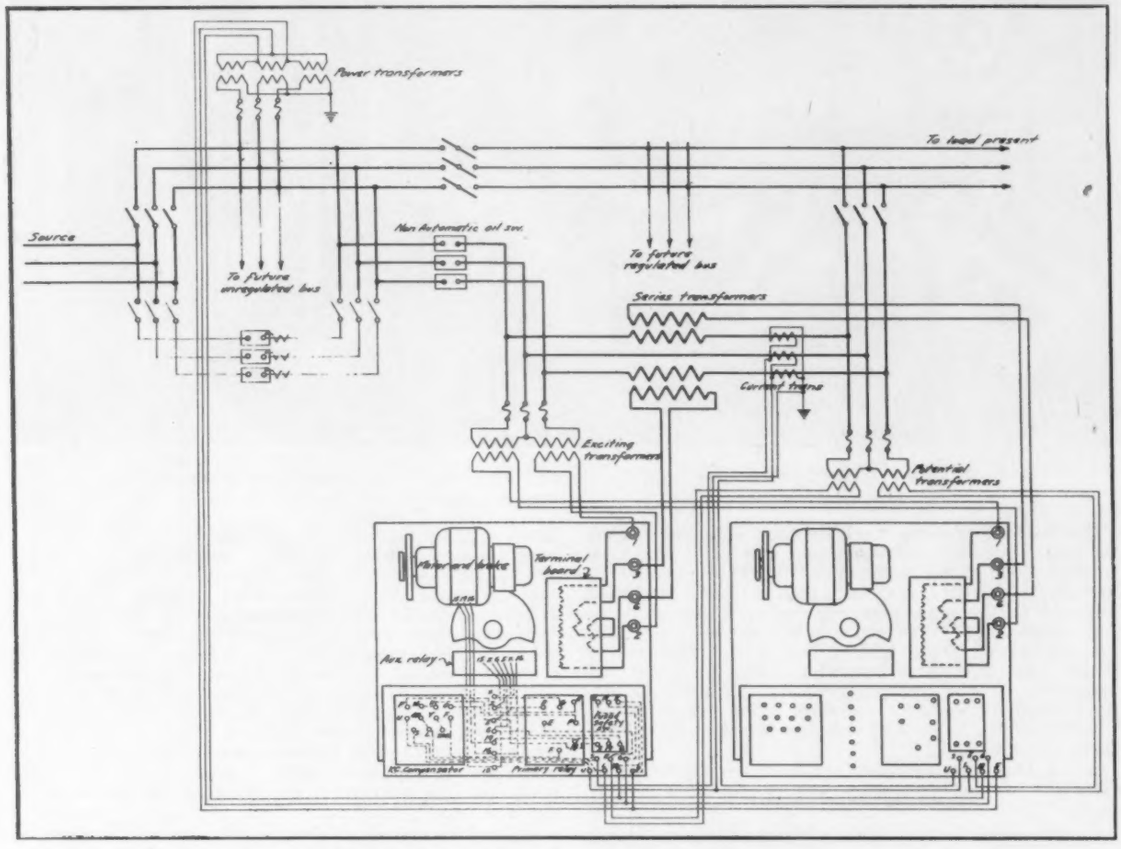
There appears to be about the same difference of opinion regarding the use of grouped single-phase regulators versus one 3-phase regulator per circuit, as there is about the 3-phase transformer versus the three single-phase transformers. The companies that favor the 3-phase transformer favor the 3-phase regulator which is perhaps natural enough as the load is likely to be better balanced and the 3-phase regulator more applicable. Conversely, advocates of single-phase transformers prefer single-phase regulators and for just as good reasons. Thus the type of distribution system rather dictates the type of regulators to use or at least appears to have bearing upon the matter. Single-phase regulators may be cut in and out of service very simply without interrupting the load, an argument in their favor from the standpoint of convenience and service continuity. Few of the companies have found it necessary to provide short-circuit reactor protection for regulators, but they all have it in mind and are prepared to install them when it becomes necessary.

The Los Angeles Gas & Electric Corporation reports having started the installation of three single-phase, 33-kv., oil-insulated outdoor reactors per circuit for current limiting and current balancing purposes. Evidently this is something new on the Pacific Coast. The Bureau of Power & Light follows a practice in large substations of providing a spare unregulated feeder connection to a transfer bus, with a set of reactors in the circuit. Any feeder may be

switched to this transfer bus for tests against possible shorts.

The Southern California Edison Company reports utilizing a stock of 2.3-kv., 3-phase regulators on 4-kv. circuits by rewinding the primaries only, reducing regulation to approximately 6 per cent boost or buck. As the neutral of the 4-kv. system always is grounded no great amount of trouble is expected due to the increased voltage stress between phases of the secondary windings.

The San Diego Consolidated Gas & Electric Company reports a situation met with in changing a 2.2-kv. system over to 4 kv. It had to do with some 2.3-kv. cables neither designed nor installed for the higher voltage operation. The problem was solved by working the cables at the usual voltage and utilizing standard 100-kva., 2.3-kv. distribution-type transformers as autotransformers to step up the voltage


Power transformers
To load present
Source
Non Automatic oil sw.
To future unregulated bus
To future regulated bus
Series transformers
Current trans
Exciting transformers
Potential transformers
Terminal board
Aux. relay
Reverse power relay
Time element
Overload trip
Reverse power trip
Time element
Overload trip
Reverse power trip
Aux. relay
Time element
Overload trip
Reverse power trip
Aux. relay
Time element
Overload trip
Reverse power trip
Aux. relay

The following outline has been used as a guide:

A. Improvements in oil circuit breaker design and manufacture.
B. Improvements in methods of applying existing types of breakers.
   1. New types of installations, including methods of reducing severity of duty to which breakers are subjected.
   2. Development in the use of automatic reclosing breakers with particular reference to the relative desirability of one, two or three reclosures, and the application of this class of duty to high-tension breakers.
   3. Use of a.c. for control and tripping of circuit breakers, involving the use of relays designed to permit a.c. operation of breakers from current transformers, and more sensitive tripping arrangements permitting the use of bushing-type current transformers.
   4. Determination of the service which may be expected from a given breaker.
      a. A review and interpretation of data gathered during the year by means of the "Oil Switch Operating Record" adopted in 1925.
      b. A description and discussion of oil circuit breaker tests which may have been carried out during the year and insofar as the results of such tests may be available for publication.
C. Development of new types of current-interrupting devices.

A part of the material intended for this report has not been received to date, but will be supplied later.

Improvements in Oil Circuit Breaker Design and Manufacture

The complaint has been general in the past that sufficient attention has not been given to the mechanical details in the design and manufacture of oil circuit breakers. The result is that a very minor, but improperly designed part in failing to function properly at times has resulted in the complete failure of the breaker itself to function when called upon. This complaint still is evident to some extent in reports received from member companies.

Another source of considerable annoyance has been the necessity of maintaining a very close adjustment of the operating linkages in certain types of high-voltage breakers. This has required repeated inspections and re-adjustments at rather close intervals. This adjustment was so critical in one case reported that the manufacturer's representative finally made a complete test readjustment of one breaker, at which time it developed that the adjustments previously made by his own service department had been faulty. It is believed rather strongly that the purely mechanical adjustment of oil circuit breakers should not be such as to preclude the carrying out and maintaining of proper adjustment with the type of personnel ordinarily available in the field.

Many improvements in design are being made, however. The substitution of monel-metal pins for steel pins in certain breakers illustrates the greater attention being given to the smaller units in the mechanical set-up. Further specific examples of improvements noted during the year are given below:

1. In Fig. 1 are shown the male and female contact parts from a 132-kv. explosion-chamber-type breaker of recent design. It may be noted that the contact retainer screws into the top of the explosion chamber enabling its removal without dismantling the latter. The disadvantage still remains, however, that the contact parts

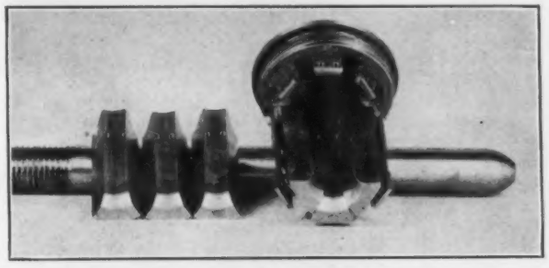


Fig. 1. Male and female contacts (partailly dismantled) of 132-kv. explosion-chamber-type breaker.

cannot be inspected in place and that it is necessary to lower the insulating tube around the explosion chamber in order to remove contact. A further improvement has been made in the design of the springs behind the contact segments. Longitudinal compression springs now are used in place of the former garter-type tension springs. With the latter it was possible for burns to occur on these springs between the segments due to the space left between them when the contact rod was in the closed position.

2. In the 220-kv. breakers employing a quick-break arcing contact the design has been improved to effect a positive release at a predetermined position of the arcing contacts and the contacts themselves have been improved. Before this change was made it was very difficult to maintain an adjustment of the arcing contacts that would effect an opening of all three phases at the same time. Arc shields and their supports in this breaker also have been improved materially in design.

3. One of the Pacific Coast manufacturers has introduced a quick-break arcing-contact mechanism which speeds up the breaking of the arc. Another Pacific Coast manufacturer has changed from the blade-type arcing contact to the butt type.

4. Up until recently one of the largest manufacturers of oil circuit breakers did not include a trip-free feature in electrically operated breakers. The operating companies have considered this

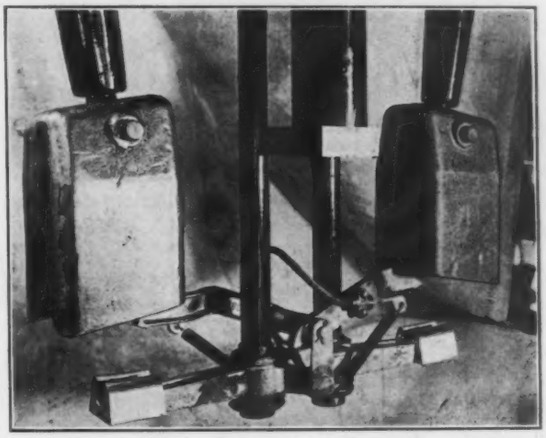


Fig. 2. Quick-break contact mechanism of 73-kv. breaker.

feature to be essential and are pleased to know that all of the motor operators now supplied by this manufacturer are trip-free and that a trip-free mechanism has been designed for solenoid-operated breakers.

5. Two manufacturers have reported the inclusion of oil dash-pots within the tanks of certain breakers to absorb the energy of the moving parts at the end of the opening stroke. It is claimed that by this means the speed of the opening can be increased considerably without the danger of excessive shock or rebound at the end of the stroke.

Certain general trends in design have been noted, among them the following:

1. A decided tendency to effect a greater ruggedness of the entire assembly and a greater simplicity in the design of the operating linkages. The accompanying illustrations will help to exemplify these features. Heavier tanks with thicker walls, stronger fastenings and improved covers make it possible to close the tanks so that they are practically gas tight, thereby eliminating the throwing of oil or flame. Fig. 3 shows the wide separation between phases used by one manufacturer. A new development in the "H" type 15-kv. indoor breaker has been made by the addition of a separate explosion chamber in the bottom of each tank and the reinforcing of the assembly inside of the tank. A new line of heavy-duty 15 to 37-kv. breakers is rated up to 3,000-amp. carrying capacity and up to 1,550,000-kva. interrupting capacity. These breakers are of the separate-tank, common-frame type and, on ratings above 500,000-kva. interrupting capacity, utilize an explosion-chamber type of contact very similar to that used in high-voltage switches. Tanks are of one-piece drawn steel without welds or riveted joints. The cast steel covers are gas-tight and oil-tight. An oil dash-pot is provided to cushion the stroke and the pole-unit operating mechanisms are internal so as to be subjected only to equal pressures. The Pacific Gas and Electric Company reports the recent purchase of six 15-kv. switches of this type which will be the first installed on the coast. Four of these switches are 600 amps. and two are 1,200 amps. rated current carrying capacities with rated interrupting capacities of 400,000-kva. It is estimated that approximately 350,000-kva. short circuit capacity is available on the 11-kv. bus at the station where these switches are to be installed.

2. Practically all heavy-duty breakers, excepting the explosion-chamber type, now employ some form of quick-break mechanism to reduce to a minimum the energy liberated within the switch. The problem of successful current interruption by means of the oil circuit breaker is the problem of successfully extinguishing the arc formed when the contacts part. The effect of arc coiling is well exemplified in the action of a fuse now on the market in which a jet of the contained insulating liquid is thrown directly into the path of the arc formed by the fuse blowing. This rapidly cools the arc and results in extinguishing it usually at the end of the first half-cycle. The introduction of quick-break contacts which stretch out the arc at a high speed and thus permit more rapid cooling is a method commonly used to accomplish this end in oil circuit breakers. Another method is illustrated by the use of the explosion-chamber principle. The speed of interruption with a quick-break mechanism is less dependent upon the amount of current interrupted. The explosion-chamber type of breaker may interrupt extremely high currents with a short duration of arc, but the effective speed of break appears to be reduced greatly for lower values of current. Developments in quick-break mechanisms are shown in Figs. 2, 4 and 6.

Comparative tests indicate that a greater speed of break may be expected from switches that are opened positively (as by means of a solenoid or heavy spring) than from those whose operation depends largely upon gravity. The revolving assembly of one type of switch recently developed is shown in Fig. 6 . This switch is of the horizontal-break type, its revolving elements operated by a heavy spring and cushioned at the end of the stroke by oil dash-pots located within the tanks. With this type of breaker the speed at which the main contacts part averages by test around 11 ft. per sec. in the 110-kv. size, and 14 ft. per sec. in the 73-kv. size. This speed is reached at the instant the arcing contacts are ready to part. As

the latter part with a speed conservatively estimated at from two to three times that of the main contacts the actual speed of separation per break is approximately 30 ft. per sec. and is independent of the arc. There are six contacts in series increasing the effective speed of break still further, although the exact multiplier to be used is a matter of some question. The California Institute of Technology at Pasadena has been coducing some investigation into the value of multigap switches, but no definite data is on hand at this writing.

3. Another welcomed trend has been toward the use of the motor operator which now is available for practically all sizes of oil circuit breakers, replacing the solenoid and resulting in a lower drain upon the control batteries and requiring smaller batteries. Types of motor operators as furnished by three manufacturers

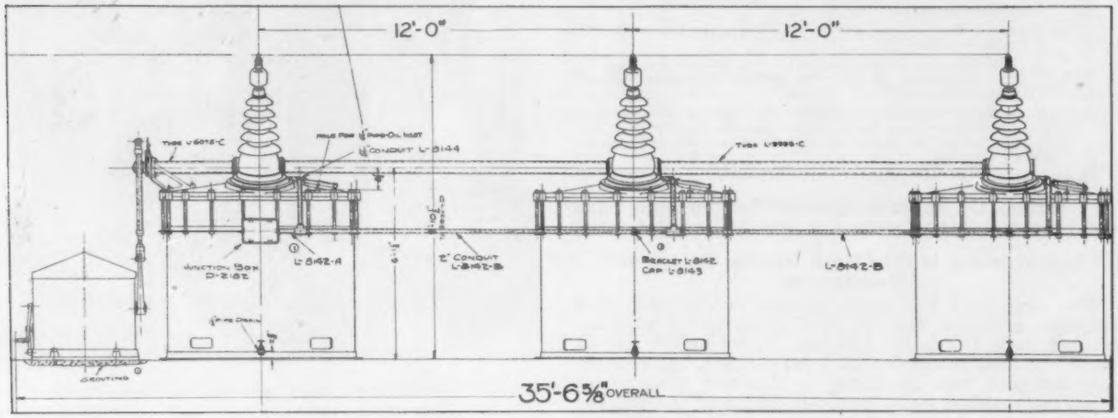


Fig. 3. Assembly of 110-kv. breaker with motor-wound spring operator, showing wide phase separation and relative size of operator housing.

are shown in Figs. 3, 5 and 7. Subsequent developments have been made in the motor-and-spring operating mechanism described in the 1926 report of this subcommittee (see Journal of Electricity, May 15, 1926, page 396) and it now is in production and in use on Pacific Gas and Electric Company oil circuit breakers up to 110-kv. rating.

Operators shown in Figs. 5 and 7 operate on the centrifugal principle and draw higher currents than the motor-and-spring type due to the fact that in the former cases the motor must furnish more energy for actually closing the switch. In the latter case a period of from 7 to 10 sec. is allowed for the motor to wind up and cock the mechanism, all the energy of which can be released instantaneously. The operator shown in Fig. 7 in a size adaptable to switches above 88 kv. requires 150 amp. starting current and 80 to 90 amp. running current. The size adaptable to switches below 88 kv. requires about 115 amp. starting current and 40 to 60 amp. running current, while the size used on small indoor switches takes 30 amp. starting current and 20 amp. running current. The motor-and-spring operator as applied to 110-kv. breakers requires 30 to 35 amp. starting current and about 15 amp running current. The current required to trip the mechanism is 5 amp. At this writing information is not available on the amount of current drawn by the operator shown in Fig. 5. All of the above are values of current drawn at approximately 125 volts d.c.

The oil situation is unchanged. One large manufacturer still contends that a single oil has not been developed to date which may be recommended for common use in the transformers and oil circuit breakers of that manufacturer. It is still hoped, however, that an agreement may be reached permitting such use with the obvious resultant advantage to operating companies.

Complaint has been made regarding the necessity for keeping on hand rather an extensive and varied stock of spare parts for oil circuit breakers. The design of this equipment has been changed so rapidly that parts applicable to a given breaker may not be applicable to a similar breaker even though it may carry the same general type designation and rating. One of the companies reported has found it necessary to develop a catalog system and maintain a centralized stock of breaker parts as a solution to this problem. Small parts which are more frequently used, such as contact fingers, etc., are kept in the more outlying stations in order to avoid great delay in effecting the necessary replacements.

New Types of Installations

No radical departure in the design of circuit breaker installations has been reported. The usual number of new breakers has been purchased including both those of eastern and Pacific Coast manufacture. The latter companies now are manufacturing breakers up to 110-kv. rating.

The Southern California Edison Company reports the use of a fused disconnect in place of oil circuit breakers on smaller jobs. This practice also has been followed by The Pacific Gas and Electric Company on transformer banks up to approximately 2,250-kva. capacity.

One of the member companies has been using a combined oil-and-air switch for sectionalizing main 60-kv. lines at smaller substations where the charging current is too high to open successfully with air switches. Transformer banks at such stations are protected by fuses. The combined oil-air switch is mounted on a light steel tower with disconnecting switches but no by-pass switch. With one such circuit breaker and a proper combination of air switches, either side of the line can be taken out of service by means of the oil-air switch leaving the station on the other side, or the switch may be disconnected and serviced without interrupting the station or opening the main line.

Reduction in Severity of Duty on Breakers

Reported failures occurring during the past year continue to indicate the tendency of systems to outgrow the capacity of installed circuit breakers. When the service limitations of a given switch, or type of switch, have been reached it is necessary to relegate the switch to a location where the service will be less severe, to find a means of increasing its capacity or to relieve it of excessive duty in its existing location. Much can be and has been accomplished by the operating companies

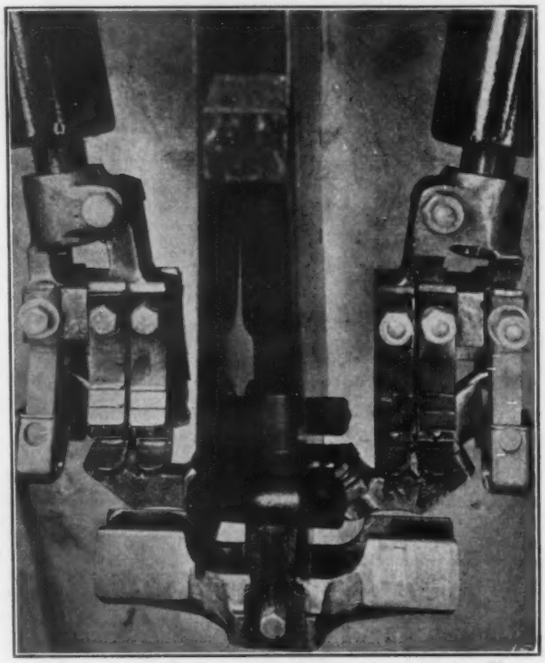


Fig. 4. Contact assembly, 37-kv. breaker.

to utilize existing breakers in an effort to avoid the purchase of any more new breakers than absolutely necessary.

The San Joaquin Light & Power Corporation has reported a proposed increase in the rupturing capacity of some 15-kv. breakers by lengthening the tanks to permit lowering the contacts and thus increasing the head of oil on the contact. Further, it is proposed to

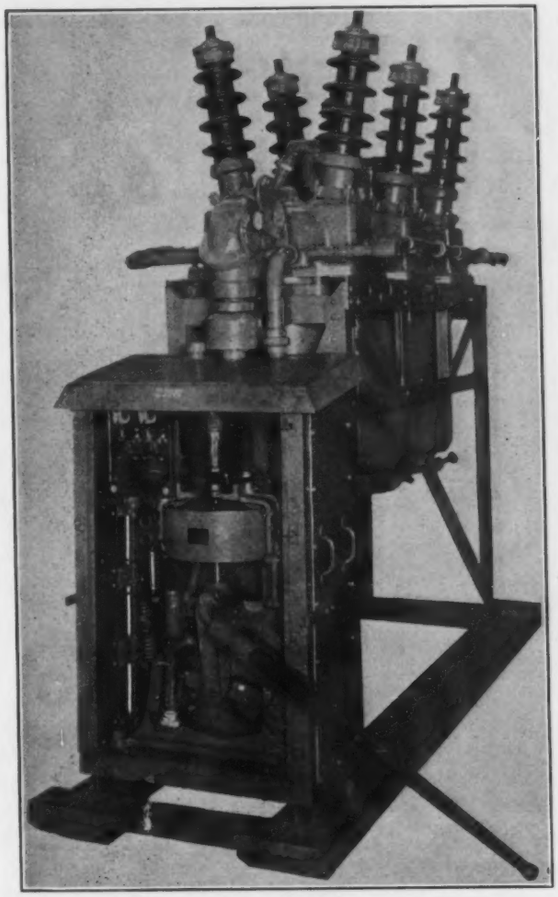


Fig. 5. Motor operator (centrifugal) mounted on 37-kv. breaker.

reinforce the tanks by means of steel channels at the tops and bottoms. It is hoped that the rupturing capacity of the switches will be approximately doubled by this means. Other companies from time to time have reported remodeling certain switches to accomplish the same end. The Pacific Gas and Electric Company has accomplished this purpose by developing a new internal mechanism with quick-break which can be installed in 60-kv. switches of its own manufacture.

The Great Western Power Company has evolved a plan at one of its stations of using a breaker of relatively high rupturing capacity to relieve a group of feeder breakers of the duty of opening fault currents. Upon trouble occurring on any feeder the main group switch opens and then relay system employed opens the breaker on the feeder affected and immediately closes the main breaker. This results in a total interruption every time feeder trouble occurs, but relay action is so timed that this total interruption is of but slight duration. The inadequate breakers thus are used merely as oil disconnecting switches.

The Southern California Edison Company is developing gradually from their present system what is termed an amplified form of a double-circuit balanced radiating feeder system utilizing existing 60-kv. feeders and adding necessary new feeders as required. The purpose of this development is to avoid a 60 kv. network covering a large area and fed from several interconnected sources of supply. Such a network would result in extremely high short-circuit currents at given points. The radial system will substitute instead a number of comparatively small groups of 60-kv. feeders radiating from separate 220/60-kv. sources. Between the 60-kv. step-down points it is expected to utilize existing outlying lines of relatively high impedance to connect one major group to another for emergency service. While this plan of development still is in its early stages, it is expected to prevent excessively high duty on breakers due to further system growth.

Automatic Reclosing Breakers

A belief has been growing that three reclosures into a case of trouble is more than is desirable. Trouble which persists after the first reclosure is little apt to clear itself before the third, and an unnecessarily high duty is imposed upon the switch by closing successively at comparatively short intervals into what may be a serious case of trouble. The Southern California Edison Company submits the interesting data covering trip-outs on automatic-reclosing breakers at attended stations for the year 1925 shown in Table I.

TABLE I—Trip-outs on automatic reclosing breakers on Southern California Edison system.

Circuit Voltage	Tripouts	Closed O.K. First Time	Per Cent
10 kv.	813	599	73.7
15 kv.	139	107	77.0
Total	952	706	74.2

Apparently the only reason that three reclosures have been adopted as more or less standard by certain companies is due to the fact that equipment supplied usually is initially adjusted at the factory for that number of reclosures. The Southern Sierras Power Company and the San Joaquin Light & Power Corporation report favoring two reclosures as sufficient. The Pacific Gas and Electric Company has been reclosing three times in the urban stations and twice at longer intervals in outlying stations.

Two member companies have utilized gang-type reclosing devices in outlying stations. This equipment originally was developed by The San Joaquin Light & Power Corporation and now is in commercial production on the coast. It is applicable readily to existing installations, is economical where a number of breakers mounted closely together are involved, and has been found dependable in service. It has been used both indoors and outdoors on breakers up to 15-kv. rating.

No application of automatic-reclosing equipment to high-tension breakers has been reported. One of the operating companies had contemplated the installation of automatic-reclosing equipment on a 60-kv. breaker controlling a stub line feeding from an isolated point on the 60-kv. network. This readily could have been carried out by the installation of a 24-volt battery and Tungar trickle charger to furnish the power necessary to operate a 60-kv. switch controlled by the so-called type "W" motor operator and a suitable reclosing relay. The idea was not put into execution; this stub feeder eventually was looped back into the 60-kv. network.

Use of A.C. for Control and Tripping

Three methods of a.c. breakers tripping utilizing standard induction-type circuit-closing relays to furnish the time delay feature have been reported, none particularly new:

1. The so-called direct-trip attachment in connection with small breakers of the switchboard mounted type.
2. Type BT transfer relays have been used in connection with standard induction type relays for current transformer tripping of breakers up to 60-kv. rating where accurate time delay is required.
3. Tripping reactors are used to by-pass current around the trip coils until the contacts on the circuit-closing relays are closed.

Circuit opening relays of the plunger type also have been used directly across trip coils on breakers up to 60-kv. rating, but this practice is being abandoned as it possesses several disadvantages, including those inherent in the plunger-type relay. Direct-connected current-transformer tripping of course is in general use on smaller breakers and has been used with bushing-type current transformers on breakers of 15-kv. rating with mediocre success mostly due to the limited capacity of the bushing-type current transformers, particularly on normal overload or low fault currents.

Determination of Breaker Capacity

In 1925 the apparatus committee developed a form for the purpose of keeping a record of automatic oil

circuit breaker operation as an aid in studying the duty imposed upon the various breakers and their behavior in the interruption of currents of various magnitudes. This form is shown on page 83 of the P.C.E.A. proceedings for 1925. By its general use it was hoped to check the capacity ratings of breakers rated by the manufacturer and to fix a capacity rating for breakers not so rated. This form has been used by several of the member companies, but its use has not been general and the information gained has been limited.

The San Joaquin Light & Power Corporation reports circuit breaker operations for 1926 as shown in Table II.

TABLE II—Breaker operations on San Joaquin system, 1926.

Circuit Voltage	No. in Service	No. of Tripouts	Average Current Interrupted	Highest Current Interrupted
110 kv.	37	101	770	2,170
69 kv.	150	434	887	4,000
33 kv.	16	27	545	890
Total	203	562		

Only six operations are reported as unsatisfactory, all on 69-kv. breakers. This is but 1 per cent of the total number of trip-outs and 3 per cent of the number of breakers in service. These breakers were more or less damaged but only one was badly wrecked.

The Pacific Gas and Electric Company has been keeping the Oil Switch Operating Record, but reports that it is being abandoned in favor of a company form which furnishes information more adapted to their particular needs. This is in the form of a record of oil circuit breaker maintenance.

The Southern California Edison Company uses an oil switch inspection and repair report which is supplemented by a special report in unusual cases. A comparative cost-analysis record is kept and summarized monthly. All circuit breakers are divided into eight classes according to their voltage and type as affecting the cost of overhaul. In this way an attempt is made to derive an analysis of the comparative cost data on the various classes. No attempt has been made to derive kva. ratings for the switches.

The Southern Sierras Power Company uses an automatic switch record containing all data on the switch and associated equipment, operation data, and record of tests and inspections.

In general, it seems to have been felt that forms already in use by the individual companies are better adapted to their own particular needs than the operating record suggested by the committee. It has been noted that several of these forms are very similar to the Oil Switch Operating Record and therefore could be made to serve substantially the same purpose.

Field Tests of Breakers

The Pacific Gas and Electric Company carried out during the summer of 1926 certain stability tests at Vaca-Dixon substation, including tests on three makes of 110-kv. and 220-kv. oil circuit breakers. Oil circuit

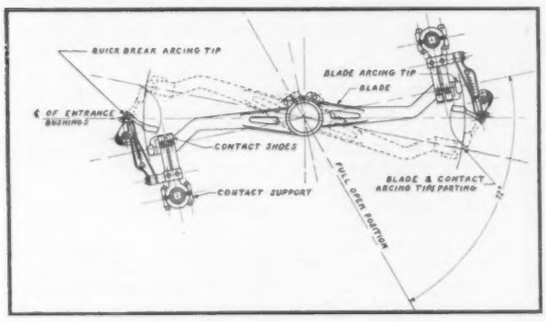


Fig. 6. Plan of blade and contact parts, 110-kv. breaker.

breaker tests, strictly as such, were made in addition and complete records were kept on all of those tests. Because of the comparative nature of the tests and for certain other reasons publication of the detailed results and conclusions has been withheld.

The California Oregon Power Company has adopted the practice of testing the time-of-opening of breakers in the field by means of a cycle counter. This company has found it possible to improve materially the performance of breakers which had been operating too slowly.

There was presented before the 1927 winter convention of the A.I.E.E. in New York City a comprehensive and interesting paper by Philip Sporn and Harry P. St. Clair of the American Gas & Electric Company on

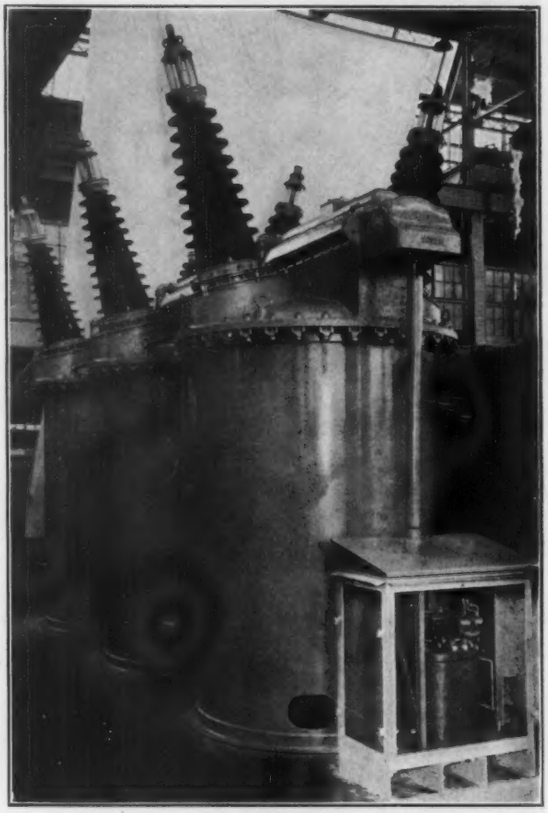


Fig. 7. Motor operator (centrifugal) mounted on 132-kv. breaker.

the oil circuit breaker tests carried out at Canton, Ohio, during 1925 and 1926. Brown-Boveri 35 and 150-kv. breakers, the Reyrolle compound-filled switch gear and two 132-kv. General Electric breakers were tested with very interesting results.

In the majority of field tests of which records have been kept and made public no mention has been made of the power factor or current interrupted. The power factor may be determined by the relative position of the arc current and voltage waves on the oscillogram, where these are sufficiently regular, or by the use of an oscillographic wattmeter. Unless the power factor is at least approximately indicated, the stated interrupting capacity of a breaker does not tell the whole story.

In the Pacific Gas and Electric Company tests a 220-kv. breaker opened a line charging current of 156 amp., drawing an arc of the same length and duration as was drawn in interrupting a fault current of 2,430 amp. An approximate ratio of 1 to 15 was maintained in several successive tests. Similarly, in tests carried out on the 100-kv. system a breaker interrupted a 900-amp. fault current in one cycle, but required 2½ cycles to interrup a 200-amp. charging current. This performance was repeated consistently. The results noted apparently are due to the fact that with a power factor practically zero, as is the case when opening charging current, the voltage is at or near its maximum value as the current passes through its zero point and the tendency to re-establish the arc is far greater than in the case of fault-current interruption. Tests also indicate that a leading (line-charging) current is harder to interrupt than a lagging current. For these reasons it is necessary to discount to some extent tests which are carried out under favorable power-factor conditions.

Also it is necessary to use discretion in comparing the results of tests conducted at different times and at different locations, unless power-factor determinations have been made and considered in arriving at conclusions.

In many tests no steps have been taken to include on the oscillogram a record of the instantaneous positions of the contacts with the result that it is difficult and sometimes impossible to tell from the record where the contacts first parted. The arc often is of such low resistance that no perceptible change is noted in the character of the current and voltage graphs until some time after the arc actually has started, with the result that in such cases erroneous conclusions are likely to be drawn.

It is suggested that, in all oil circuit breaker tests that may be carried out in the future by the operating companies, steps be taken to include records of power factor and instantaneous contact position.

New Types of Current Interrupting Devices

The development of new types of current-interrupting devices has been slow. Manufacturers of commercial circuit breakers, while best equipped both as regards personnel and equipment to develop new ideas, either have accomplished little or have refrained from making their accomplishments public. An interesting development has appeared during the year, however, in the form of the vacuum switch of Professor R. W. Sorensen and H. E. Mendenhall of the California Institute of Technology, Pasadena. Descriptions of this switch have appeared in the technical press from time to time, and it was made the subject of a paper before the 1926 Pacific Coast A.I.E.E. convention at Salt Lake City. This paper was published in the journal of the A.I.E.E. for December 1926. In tests described in the paper the switch repeatedly opened short-circuit currents of as high as 926 amp. at 41.5 kv., always interrupting the arc at the end of the first half-cycle and without burning or pitting of the contacts. While development has not been made as yet to the point of commercial application, the prospects are encouraging.

The oil circuit breaker at present is the only form of device in practical use for interrupting the flow of currents of considerable magnitude and under high pressures. As has been previously stated, the problem of the oil circuit breaker is the problem of successfully cooling and extinguishing the arc formed when the contacts part and all efforts have been directed toward accomplishing that end. It is possible that in endeavoring to reduce an effect, sufficient thought has not been given to the possibility of eliminating the cause.

Recommendations

The following specific recommendations are offered:

1. That manufacturers of oil circuit breakers continue to devote attention to the simplification of the mechanical features, to the end that adjustments may be made less critical and mechanical failures eliminated.

2. That operating companies give further thought to the development of methods for reducing the severity of service on breakers.

3. That automatic reclosing duty be limited to not more than two successive reclosures and that consideration be given to the possibility of limiting to one reclosure where any doubt exists as to the capacity of the breaker to interrupt the short-circuit current available.

4. That thoughtful consideration be given to the appreciable economies that may be effected through a more thorough knowledge and a better understanding of the actual service in performance of various types of oil circuit breakers, as brought out by field tests; that a real effort be made to authorize and carry out such tests from time to time; that the burden of making them be distributed among those companies operating systems of sufficient capacity to derive data of value; and that the detailed records of these tests (including records of power factor and instantaneous contact positions) be published for the benefit of all member companies.

Hydraulic Power Committee Reports[7]

Evaporation from Lakes*

By N. W. CUMMINGS, California Institute of Technology.

Abstract

It long has been customary to estimate evaporation from lakes on the basis of observations of pans placed in the vicinity, but there has been no means of showing conclusively that the error thus involved is not excessive. Thus pans of different sizes are known to have different depths of evaporation[1] and obviously this means that the depth of evaporation from a lake cannot in general be the same as that from any particular pan. If the theory described in this paper proves to be correct a substantial progress will have been made in the evaluation of evaporation from lakes.

Evaporation can be determined by the aid of the first law of thermodynamics in such a way that wind velocity need not enter the calculation. Air temperature and humidity enter only as terms in a correction which can have a relatively small average value under typical conditions. A method of finding the difference between incoming and outgoing radiation from observations on a well-insulated pan is described and also a method of finding the ratio of sensible heat to latent heat transmitted through the air-water surface. These quantities can be used in estimating evaporation from an actual lake if proper corrections are made for storage of heat in the water, expansion of water, and heat conveyed by inflowing and outflowing water. Two proposed engineering applications are outlined.

Theory

Evaporation obviously must be determined uniquely by the energy that is rendered available for that purpose. Expressed as an equation this is

$$E = \frac{I - B - S - K - C}{L} \qquad (1)$$

where E is the evaporation expressed in centimeters of depth, I is the incoming radiation per sq.cm. of surface, B the back radiation to the sky, S the heat consumed in warming the water, K a correction due to heat derived from the air or given up to the air as sensible heat, C a combined correction for heat leakage through the walls of the container, expansion of the water and, in the case of a lake, for heat carried by flowing water. It is supposed that all the quantities in the numerator are expressed in gram-calories per sq.cm. of open water surface and are to be integrated over the same time interval[2] as E. The heat of vaporization of water expressed in gram-calories per cp.cm. is denoted by L.

If it is possible to observe all the elements on the right side of equation (1) except K, then to compute K by means of a certain equation derived by I. S. Bowen that presently will be stated, and finally to compare the right side with the observed evaporation placed on the left side, the agreement between the right and left sides not only will constitute a check on Bowen's equation, but it will show also whether or not evaporation can be

[1] R. B. Sleight, Jour. Ag. Res. X 209 (1917).

[7] **J. M. Gaylord,** Southern California Edison Company, chairman. **E. A. Crellin,** Pacific Gas and Electric Company, vice-chairman. **The California Oregon Power Company:** P. O. Crawford, J. F. Partridge, E. G. Waters. **Great Western Power Company:** R. F. Krafft, C. M. Mardell. **Joshua Hendy Iron Works:** C. B. McAulay. **Pacific Gas and Electric Company:** C. DeWitt, Walter Dreyer, F. R. George, Hector Keerling, L. H. Roberts, W. D. Skinner, I. C. Steele, R. W. Wilkins. **Pelton Water Wheel Company:** C. B. Foulds, R. S. Quick. **San Joaquin Light & Power Corporation:** H. K. Fox, N. R. Hodgkinson, J. W. Jourdan, C. E. Pearce, Oren Reed, C. P. Rhine. **Southern California Edison Company:** J. W. Andree, R. C. Booth, S. F. Coghlan, R. B. Lawton, R. M. Peabody, J. E. White. **The Southern Sierras Power Company:** G. M. Wills. **Truckee River Power Company:** G. G. Devore. **Western States Gas & Electric Company:** J. R. Johnson, M. C. Wheyland. **Westinghouse Electric & Manufacturing Company:** H. S. Warren.

*Note. The research covered by this report was carried out by Mr. Cummings at California Institute of Technology, Pasadena, and was financed in part by the P.C.E.A. The work is an attempt to introduce a rational scientific method into the study of evaporation. The substance of the report was presented at a meeting of the hydraulic power committee at Los Angeles, Sept. 1, 1926. A brief resume of the discussion at that meeting follows the report.

[2] It may not be obvious that S and C thus can be expressed, but if the total amount of heat stored in the entire lake or entering by methods to which C refers be divided by the lake surface area, a definite part of each of these total quantities of heat will be allocated to a column under each sq.cm. By thus centering attention upon a column of water having a sq.cm. cross-sectional area and a depth equal to the average depth of the lake all the quantities in the numerator are made comparable and can be expressed in the same units.

computed without making any measurements on wind velocities, as the general theory demands. The elimination of wind from evaporation calculations is one of the fundamental ideas previously emphasized by the present writer.[3]

Such a comparison virtually has been made, though in order to avoid the necessity of measuring I and B directly a slight variant on the above procedure was adopted as follows:

First introduce the quantity R as defined by the relation

$$L\,E\,R = K \qquad (2)$$

This means that R is the ratio of sensible heat swept away by the wind to latent heat carried off by the vapor. It has been discussed by Anders Angstrom, the Swedish Meteorologist[4], who finds that R averaged less than 0.10 for the North Atlantic during the forepart of September, 1905. Angstrom concludes that R in general is relatively small, but until now it has been extremely difficult to obtain extensive and reliable information with respect to this quantity. However, Dr. Bowen[5], physicist at the Norman Bridge Laboratory, California Institute of Technology, recently has developed an equation which makes it possible to compute R from ordinary atmospheric data without knowing either the sensible heat or the latent heat, separately. His equation is

$$R = 0.46\,\frac{t_1 - t_2}{p_1 - p_2} \qquad (3)$$

where $t_1 - t_2$ is the difference between the temperature of the air and that of the water surface, and $p_1 - p_2$ is the difference between the vapor pressure of the moisture in the air and the pressure this would have if the air were saturated. Equations (2) and (3) together serve to eliminate K from equation (1) and express the new quantity R in terms of easily measurable magnitudes.

Next, after substituting L E R for K in equation (1), the quantity I — B is solved for and the resultant quantity will be denoted by H. This really is the difference between the solar and sky radiation which penetrates the water surface, and the energy which the water body radiates back to the sky. For convenience it will be called the **heat budget per sq.cm. of surface.**

$$H = I - B = S + LE\,(1 + R) + C \qquad (4)$$

Now I must be the same for all water surfaces exposed to the same external conditions whether the water bodies are shallow and heat up rapidly, or deep and

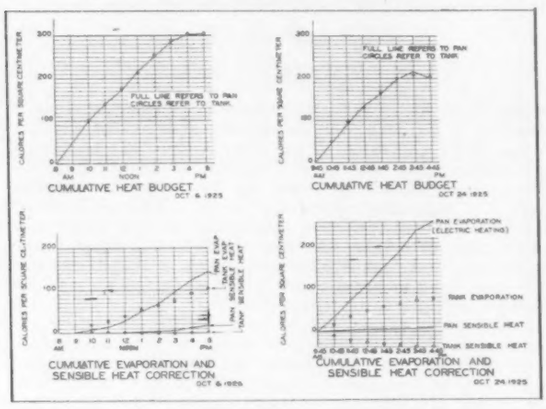

CUMULATIVE HEAT BUDGET
CUMULATIVE HEAT BUDGET
CUMULATIVE EVAPORATION AND SENSIBLE HEAT CORRECTION
CUMULATIVE EVAPORATION AND SENSIBLE HEAT CORRECTION

Figure 1.

therefore change slowly in temperature. This equality does not necessarily hold for B, however, because if two bodies of water have different temperatures they must radiate energy at different rates. For two surfaces exposed to the same conditions it is possible to write equation (5) from equation (4), because of the equality of I_1 and I_2.

$$B_1 - B_2 + S_1 + C_1 + LE_1\,(1 + R_1) = S_2 + C_2 + LE_2\,(1 + R_2) \qquad (5)$$

Since Bowen has pointed out that water radiates practically like a black body because it almost completely absorbs low-temperature radiation, we may compute $B_1 - B_2$ by means of Stefan's law, thus

$B = 49.5 \times 10^{-10}\,T_4$ gram-calories per sq.cm. per hr. (6)

(See also Abbott, Annals of the Asthophysical Observatory, Vol. IV.) Because $T_2 - T_1$ in this application does

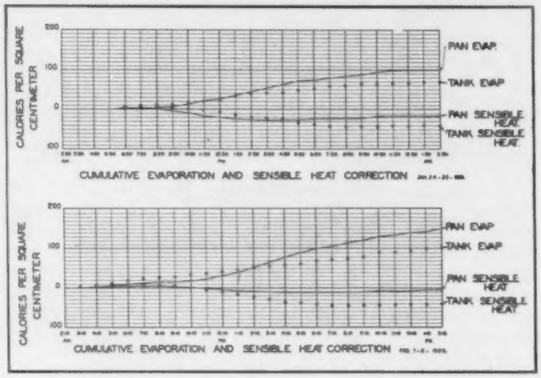


Figure 2.

not exceed 15 deg. C and T_2 and T_1 always are between 0 deg. C. and 35 deg. C., $B_1 - B_2$ may be calculated with sufficient accuracy if equation (6) is differentiated with respect to T:

$$\frac{dB}{dt} = 198 \times 10^{-10} \times (290)^3 \qquad (7)$$

$$= 0.5 \text{ calories per sq.cm. per deg. per hr.}$$

Then multiply by the difference in temperature of the two surfaces. These considerations make it possible to subject equation (5) to experimental test.

Experimental Procedure

The bodies of water were contained in a tank and pan, the two vessels being copper lined but so dissimilar in size and shape that on the basis of well-known facts with respect to evaporation from tanks and pans they could be expected to lose water at substantially different rates. The volume and therefore the heat capacity of the tank was about 50 times that of the pan. Actual dimensions were as follows:

	Tank (ft.)	Pan (ft.)
Length	4.96	2.00
Width	4.96	2.00
Depth	5.06	0.67
Depth of water below rim	0.1	0.05

Both vessels were insulated thoroughly, but corrections were applied to take account of such small quantities of heat as did leak through the walls.

Evaporation loss was determined in the usual way by observing the amount of makeup water required to bring the level back to a predetermined height defined by a wire projecting upward from beneath the surface. The error of this measurement lay between 0.1 and 0.2 mm., depending upon how badly the surface was disturbed by wind. The surface temperature of each body of water was measured by means of a mercury-in-glass thermometer graduated in tenths, but for the change in temperature a Beckman instrument was used, the water being stirred just before the volume temperature was read. The air temperature and absolute humidity were determined with an Assman psychrometer. (See Fig. 1.)

Since equation (3) was derived for instantaneous values of the variables there should be, strictly speaking, a continuous record for the entire time interval, but hourly readings are a good substitute. The first run was made Oct. 6, from 8 a.m. to 5 p.m., and the second run Oct. 24 from 9:45 a.m. to 4:45 p.m. In this case the pan was maintained at 30 deg. C. by a measured amount of electric energy, and proper allowance was made in computing H. The third run extended from

[3] Jour. of Electricity, Vol. 46, p. 491, May 15, 1921.
[4] Geografiska Annaler, H. 3, p 13 (1920).
[5] I. S. Bowen, Phys. Rev. 27, p. 779 (1926).

5:20 a.m. Jan. 24 to 2:20 a.m. Jan. 25, while the fourth was from 2:10 a.m. Feb. 7 to 2:10 a.m. Feb. 8.

Results and Comparison with theory

Equation (4) was used to compute H, the heat budget per sq.cm. or resultant radiation for each body of water and for each time interval. This time interval is the interval between successive readings, in most cases one hour. The correction $B_1 - B_2$ was calculated by means of equation (7) and applied to the budget for the pan in order to reduce H for the pan to the temperature of the tank, as indicated by equation (5). This process, then, should have brought the two budgets into agreement. (See Fig. 2.)

For the purpose of comparison cumulative heat budgets were used. These were obtained by a process of continued summation as follows: For each vessel the budget for the first hour was added to that for the second hour, then the budget for the third hour was added, then the fourth and so on. Each series of these continued summations was plotted against time, full lines representing pan budgets with the $B_1 - B_2$ corrections, and circles referring to the tank. According to equation (5) the circles should fall on the lines. The discrepancy is within experimental error. (See Fig. 3.)

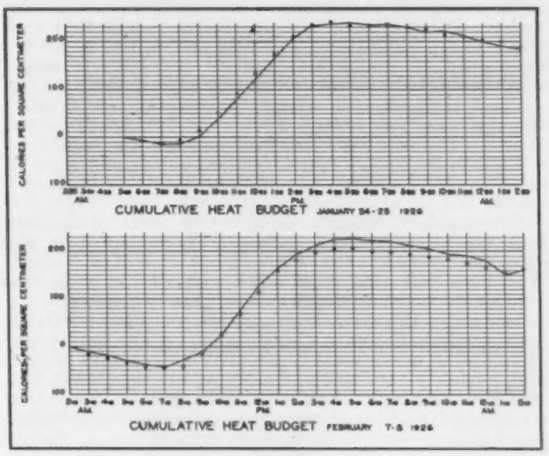

CALORIES PER SQUARE CENTIMETER
CUMULATIVE HEAT BUDGET JANUARY 24-25 1926
CALORIES PER SQUARE CENTIMETER
CUMULATIVE HEAT BUDGET FEBRUARY 7-8 1926

Figure 3.

It may readily be understood that in working in the open air, where practically every magnitude involved in the entire experiment is changing incessantly, various sources of error must occasionally converge to produce an exceptionally large discrepancy between the heat budget curve for a short part of their length, although the only conspicuous cases are those of the middle of the day on Jan. 24 and the time of the maximum cumulative heat budget of Feb. 7. A continuous run of several days' duration would cause such a large heat budget to accumulate that the combined errors due to all sources would become negligible in comparison.

To avoid the possibility of disastrous interruption such a program must be carried out during the summer when there is little or no danger of rain because the two vessels cannot be depended upon to catch the same depth of rain. If done successfully such an extended run actually might check the numerical value of the coefficient 0.46 in Bowen's equation[6].

Although in the two cases mentioned the error is approximately 20 calories or 10 per cent of the maximum budget it is not sufficiently large in any of the runs to obscure the validity of Bowen's theory. The run which confirms this theory best is that of Oct. 24 when the pan was artificially heated. In this case the departure between the two cumulative sensible-heat curves is several times as large as the departure between the heat-budget curves. It is perfectly obvious that if Bowen's correction were not applied in this case the two heat-budget curves would diverge widely from each other.

While this run furnishes the most striking example of the necessity for applying equation (3) each of the other three runs shows it in some degree. Thus the difference between the cumulative sensible-heat correction curves in the latter part of all the runs is large in comparison with any discrepancy in the cumulative heat-budget curves. It is not fair to draw conclusions from the first part of the runs because at this time the quantities under comparison have not become large in comparison with unavoidable errors.

From 4:20 to 5:20 p.m. on Jan. 24 the ratio R has the remarkably high numerical value of 1.37 and the complete data show that it was numerically greater than 0.30 during a large part of each complete run. Yet the discrepancy in the curves is nowhere greater than 10 per cent of the maximum heat budget and generally is much less. The variation of R for the tank is far from being in phase with the variation for the pan. For example on Jan. 24 the minimum R for the pan came at 9 a.m. whereas for the tank it came at 5 p.m. During a great deal of the time the ratios have opposite signs. These facts show that Bowen's correction really is significant. Without applying the correction it would be impossible to obtain an agreement so long as hourly changes are being dealt with.

The case for longer periods may be quite different, however. The average value of R does not exceed 0.27 numerically for either pan or tank in either of the long runs. Although R for the tank is relatively large during the day-time runs of Oct. 24 for the pan it is not because the pan was heated artificially. Doubtless R would not have been as large as 0.27 if the tank water had not been stirred so as to keep at the surface the cold water which ordinarily would have remained below. This inference is justified by the fact that the average R was in the direction from air to water. This suggests that although R takes on large values at times, nevertheless when averaged over long intervals of time it may be a small fraction as Angstrom found for the conditions he investigated.

Thus it is seen that the use of Bowen's theory brings into agreement the two heat budgets which, it is believed, on the basis of the conservation of energy ought to agree. In other words, the theory works and on this ground it is justified. The foregoing therefore is a correct method of computing H. It follows that the pan can be taken to a lake, H may be computed as has been done here and, after making the $B_1 - B_2$ correction, the computed H may be applied to the lake. Then S, R and C may be determined for the lake and R computed by the following equation:

$$E = \frac{H - S - C}{L\,(4\,R)} \qquad (8)$$

which is obtained from (1) by substituting L E R for K and solving for E.

This can be taken as the primary standard for calibrating all other methods of determining like evaporation. Other equations such as that famous one that bears the name of Dalton contain certain empirical constants which can be evaluated only when a series of real lake evaporations are known. The procedure outlined herein furnishes the only method thus far devised for ascertaining these required lake evaporations with satisfactory precision and reliability. Like most primary standards this is difficult to apply although under certain conditions it is possible to shorten the work considerably.

Upon superficial examination it might appear that this research is nothing but a comparison of evaporation from two vessels of different dimensions, with certain corrections applied. As a matter of fact it is more than that. While it is true that H has been determined by means of observations on the pan nevertheless this was merely an expedient that had to be resorted to because as yet no technique has been developed for measuring B with satisfactory precision and convenience. If such a technique ever is developed then lake evaporation can be found without using any pan and without making measurements on wind velocity. Moreover, if it turns out that the effect of the atmosphere in causing a transfer of sensible heat really is small under conditions that might be called normal, which is not unlikely, then air temperature and humidity need enter the calculations only as terms in a relatively small correction which for many purposes may be neglected entirely. Obviously, then, it is worth while to accumulate as much information as possible in regard to the value which R assumes at various places and at various times of the

[6] Since this paragraph was written such a run has been made by Mr. Richardson with remarkably close agreement. The results will be published in the future.

year. This can be done easily by means of Bowen's equation when the requisite wet and dry-bulb and water temperatures become available.

Suggested Engineering Applications

The use that can be made of the foregoing facts and principles will depend upon what particular kind of information is desired and also upon what data and facilities are available. Two highly practical applications are described in the following:

One which it would be desirable to make in the near future is the testing of some of the most promising empirical equations that have been proposed for expressing evaporation in terms of various atmospheric elements. Such an investigation would be somewhat expensive, but it certainly would repay the cost because if any of these equations really are capable of expressing the facts with sufficient precision, they without doubt will be extremely useful when once their validity has been established. Procedure would be as follows:

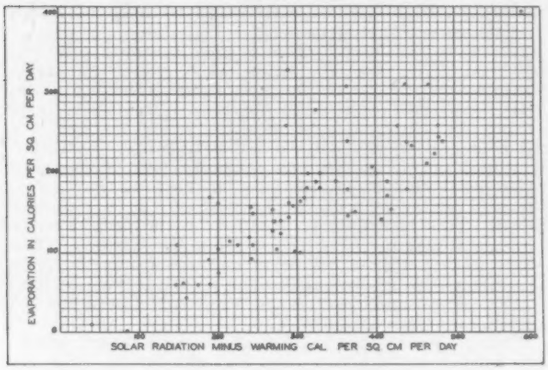


Figure 4.

A representative body of water should be chosen for which the inflow and outflow are not sufficiently large to require any appreciable correction for heat carried to the lake or away from it with the water. The contours of the lake should be known. A well insulated pan such as has been used in this research should be installed near the lake and hourly readings continued for at least one month. The data should include:

1. Lake temperatures at all depths at the beginning, again at the end of the time interval chosen and preferably once or twice between. A series of subsurface temperatures can easily be run in one hour.
2. Hourly lake-surface temperatures.
3. Hourly surface and body temperatures for the water in the pan.
4. Hourly wet and dry-bulb readings over both lake and pan.
5. Hourly wind movement.

From this data a monthly evaporation can be computed by the aid of equation (8) which will constitute a more reliable estimate of the actual lake evaporation than ever it has been possible to make heretofore. Having this reliable estimate of lake evaporation together with all the atmospheric data needed, including wind velocities, any empirical equation may be selected and its constants determined. This will put the empirical equation upon a reliable basis, if it happens to be capable of expressing the facts consistently so that thenceforth the equation can be used, and the pan with its hourly evaporations may be dispensed with. The following fact should be carefully borne in mind, however. **Before any empirical equation is ever used for computing lake evaporation it should first be subjected to a severe test of this kind to make sure that it is actually capable of giving results that are in agreement with real lake evaporations.**

A second application of the principles set forth in the first part of this paper may be described as follows:

In spite of the apparent fickleness of the atmosphere there is a certain constancy in it. For example, the average temperature for any one month does not vary more than a few degrees from year to year or from place to place over vast areas. By analogy it is logical to expect certain regularities in the behavior of the ratio R which, when they are definitely known, will make it possible to estimate R without all the detailed information needed for the experimental verification of the theory underlying this research. The same thing applies to the $B_1 - B_2$ correction. If an acquaintance once is established with the meteorological behavior of these quantities then a pan placed in the vicinity of a lake can be corrected so as to give the lake evaporation and without necessitating observations more frequently than once a day or perhaps once a week. Great possibilities lie in the use of recording instruments when it is known how to interpret the record.

In line with this thought an attempt was made to find a semi-empirical relation between the daily incoming radiation as measured by a weather bureau recording pyrometer and the evaporation from the tank. This experiment extended over a period of several months during the spring of the year when there was a wide range of weather conditions.

Results were extremely encouraging and seemed to indicate that a remarkably simple relation exists between evaporation and solar radiation when proper account is taken of the storage of heat in the water.

Evaporation and Solar Radiation Intensity

In view of the difficulties involved in taking account of atmospheric conditions, even by the aid of Bowen's theory it was thought worth while to try the expedient of neglecting them and taking account of nothing but solar radiation and changes in heat content of the water. It is perfectly obvious at the outset that such a procedure cannot be rigorously sound, but engineers frequently are compelled by stern necessity to resort to methods that are not completely explained by theory.

The real question is whether the average error, when observations are extended over a sufficiently great length of time, will be small enough or consistent enough to make this approximation sufficiently good to have any real value. The answer seems to be in the affirmative.

General facts relative to reflection seem to indicate that the total reflected energy is proportional to the total energy and is less than 10 per cent of it. Moreover, back radiation must act somewhat like reflection because on a cloudy day which is usually followed by a cloudy night the incoming radiation and back radiation both are low, but on a clear day and night both types of radiation are relatively high. There is then a general tendency for back radiation to act somewhat like reflection although physically it is quite different. In very humid weather there will be some incoming radiation but there may be little or no evaporation or change of temperature. The whole of the energy received may be radiated back under such conditions.

It is not unreasonable to expect, then, that there will be a fairly definite linear relation between evaporation, as one variable, and incoming radiation minus warming, as the other. This expectation seems to be borne out

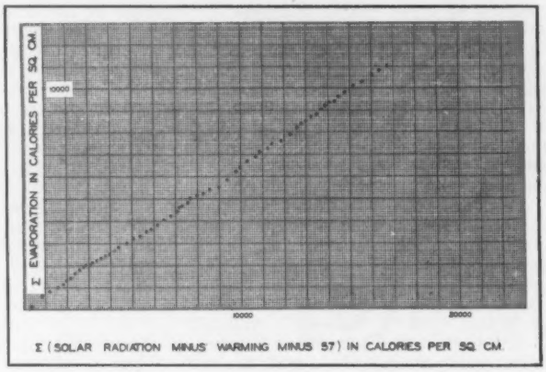


Figure 5.

by such observations as it has been possible to make during the spring of 1926 as shown by the curves in Figs. 4 and 5. There were many interruptions caused mainly by rainy weather but, on the whole the dispersion is small compared to that shown by curves usually obtained by plotting evaporation against wind or temperature or humidity.

Figure 4 represents the evaporation plotted against the difference between the "insolation" or the energy received from the sun and the amount consumed in warming the water, each day taken by itself. In practice, however, the daily evaporation is not the thing

desired. What is wanted is the accumulated evaporation over a month, a whole season, or a year.

Figure 5 shows how this may be found from a knowledge of temperature changes and radiation intensity. If 57 calories is subtracted from insulation minus warming for each day and the continued summations found and plotted against continued summations of evaporation a more useful relation is obtained, which is shown in Fig. 5. Both curves relate to the tank.

Such dispersion as does exist in Fig. 4 is due largely to the storage and subsequent release of heat by the insulating material. Unavoidable errors in measuring evaporation and change of temperature also are relatively serious. Over a period of several days these variations and errors tend to cancel out and this fact explains in large measure the greater smoothness of the curve in Fig. 5.

These observations covered a very wide range of weather conditions, extending from Jan. 19 to April 23. Much cloudy weather is included as well as many cloudless days. The water temperatures changed from 9.0 deg. to 21 deg. with the usual seasonal variations of atmospheric conditions. It is easy to believe, therefore, that the smoothness of the curve in Fig. 5 is not an accident. Probably it would be obtained at other times and other places although the constants might change somewhat. Nothing but a new series of observations can settle this point conclusively.

By computing the daily evaporation upon the basis of the equation $E = 0.65\ (I\text{-}W\text{-}57)$ where E is the evaporation, I the insulation as measured with the pyranometer and W the heat consumed in warming or cooling the water, an average daily error of 20 per cent is obtained. It is very difficult to determine the average temperature more accurately than 0.05 deg. or the evaporation more accurately than 0.1 mm. A combination of two such errors would account for about 7.5 per cent of the above 20 per cent. The remaining 12.5 per cent must be assigned to storage of heat in the insulation and to irregular fluctuations in the back radiation and conduction to the air.

It is extremely improbable that the constants of this equation will have to be changed greatly in order to make the equation hold satisfactorily in a large proportion of the localities where it is likely to be tried, because the only thing that could change the constants would be a change of weather conditions. Now, if any change that is likely to be encountered in most parts of the United States could demand a material change of the constants, it is likely that such weather variations as already have been encountered in Pasadena, Calif., while this experiment has been in progress would have required that the constants be changed from month to month. Actually, however, the same constants were observed to hold from the middle of January to the middle of April.

Many helpful suggestions were received from Dr. Millikan and other members of the faculty of the California Institute of Technology and suggestions and assistance were given by Burt Richardson in carrying out the observations and computations.

Discussion by O. A. Wait and Others

Value of Evaporation Data

Evaporation from lakes is one of the minor factors in the study of water supply. Although there is exact knowledge of the amount of annual evaporation it is safe to assume that it is relatively constant from year to year. At least it is much less variable than precipitation. It is the practice of the Southern California Edison Company to assume a constant annual evaporation of 48 in. from its Huntington and Florence Lake reservoirs. This is distributed by months as follows:

Month	Amount		Month	Amount	
	%	Actual		%	Actual
Jan.	3	1.44 in.	August	12	5.76 in.
Feb.	4	1.92 in.	Sept.	9	4.32 in.
March	7	3.36 in.	Oct.	7	3.36 in.
April	10	4.80 in.	Nov.	4	1.92 in.
May	13	6.24 in.	Dec.	3	1.44 in.
June	14	6.72 in.			
July	14	6.72 in.	Total	100	48.00 in.

Other member companies follow similar methods. This practice appears to be sufficiently accurate for all purposes. In fact for general estimating and such work as forecasting water-power resources evaporation usually may be neglected since it is a small quantity compared with the other variable factors which must be considered.

An accurate running record of evaporation undoubtedly would be of scientific interest and of some value to power companies. Most of the large hydroelectric companies are keeping or at some time have kept evaporation records by means of floating or land pans. This would indicate that these companies consider the information obtained to be worth its cost. One company states that it has maintained an evaporation station continuously since 1921 and is considering the installation of additional stations.

An exact knowledge of evaporation would be useful in the following ways:

1. As a factor in forecasting water supply.
2. In reconciling records of inflow and use at storage reservoirs.
3. In apportioning water between joint users from reservoirs.
4. In possible contract or legal relations with other power or irrigation interests.
5. To irrigation engineers and possibly to power engineers in planning new projects where evaporation losses may be an important factor.

Difficulties with Evaporation Pans

The difficulties with the ordinary evaporation pan, either of the floating or land type, are well known. The floating pan must be protected from wave action and from severe wind since either may carry water into or out of the pan and vitiate the results. The effect of the size, depth, color and material of the pan is imperfectly known. A land pan is subjected to different conditions and must be calibrated by a floating pan and even then no one can tell whether either pan gives readings which are representative of the average condition existing over the lake.

In fact it seems to be fairly well established that any pan represents conditions only in its immediate vicinity.

Due to the roughness of the topography surrounding the usual mountain location of the power reservoir the air currents are disturbed, causing the temperature and humidity to vary at different parts of the water surface. This condition makes it impossible to obtain any great precision in estimating evaporation from any reasonable number of pans. Furthermore, any ratio which might be established between pan and lake evaporation would not hold when precipitation is taking place either as rain or snow.

It is apparent that present methods are unsatisfactory and uncertain at best and any step toward placing this work upon a vigorous basis should be given support.

The rigorous demonstration of I. S. Bowen checked by the experimental work of N. W. Cummings at California Institute of Technology, Pasadena, Calif., strongly supports the soundness of the Cummings method. This method is founded on the conservation of energy and can be accepted as true as applied to an elemental area of water surface. In attempting the practical application to a large reservoir, however, some uncertainties and practical difficulties will be encountered.

Number of Readings Required

The number of readings necessary to obtain proper averages over the area of the lake and throughout the period of test must be decided arbitrarily and there is little information as to the probable error involved in assuming averages from any limited number of readings.

Based on the variation of temperature readings obtained in his experiments Dr. Cummings states that the following readings should be taken in estimating evaporation from a reservoir of the size of Huntington Lake which is about 1 mile wide and 4½ miles long:

1. Daily evaporation and temperature readings of an insulated pan.
2. Readings from four recording thermometers distributed over the lake.
3. Readings from recording thermometers in the inflowing and outflowing streams.
4. Quantity measurements of inflow and outflow.
5. Monthly temperature soundings of the lake.

It is difficult to discuss the precision of the results which would be obtained by such a survey but this may be considered to be the minimum number of readings to be taken if reasonably accurate results are to be obtained. With the exception of the temperature soundings the records all could be made by one attendant but

he should be a skilled ovserver. The temperature soundings would require an additional man.

Difficulty of Obtaining Accurate Readings

Conditions of practical application are far different from those of laboratory test and the same difficulties that occur with the present floating and land pans must be overcome. Waves may build up on the lake to such an extent that spray will be blown into the air and evaporated while the insulated pan must be protected sufficiently to prevent water being blown out mechanically.

The measurement of outflow is required for operating purposes but the inflow usually is made up of many streams, springs and direct runoff and can be measured only as accumulated storage. The inflow may come from hot springs or it may contain ice or snow which melts in the lake requiring large amounts of heat not accounted for in the temperatures of the inflow. The determination of the average temperature and heat content of the inflow is largely a matter of guesswork. The uncertain question of loss through seepage also must be considered.

Dr. Cummings considers the lake as thermally insulated and that there is no net heat transfer between the earth and water. This assumption is open to question since the floor of the reservoir is uncovered as water is withdrawn and may be blanketed with ice or warmed by the sun when the reservoir is being refilled. The application of the Cummings formula to an ice-covered lake has not been demonstrated.

The value of the possibly more accurate information to be obtained by this method is limited and it is doubtful if many power companies would authorize the additional expense to carry on this work.

Evaporation from Pyranometer Readings

Dr. Cummings mentions an empirical method which appeals strongly to the power engineer although it may not meet the more exacting requirements of the purely scientific mind. This method consists in establishing a simple relation expressed as a curve between solar radiation and evaporation. While this method neglects several minor corrections and possibly does violence to many theoretical considerations such as the effect of wind, yet it is simple and from Dr. Cummings' experiments it appears that it may prove to be sufficiently accurate for most purposes.

Solar radiation can be measured by means of the pyranometer which consists essentially of thermo couples mounted in black-and-white surfaces, the elements connected to a recording milliammeter. The indications are proportional to the solar energy received by the instrument and it seems entirely possible to develop a scale which would read directly in depth of evaporation. Such a method would give continuous records of evaporation at very silght expense and if perfected would constitute an important step in advance. If such instruments were available there is little doubt that the power companies which have become discouraged over the present methods would be sufficiently interested to install new stations. Records of solar radiation are being kept at a few points by the U.S. Weather Bureau and such records may prove to be useful to engineers in computing evaporation from projected reservoirs in the vicinity. Further investigation of this simple method is desirable.

N. W. Cummings' Answer to Discussion

It should be borne in mind that the purpose of this investigation was to lay a strictly scientific foundation for evaporation studies by providing a method of physically measuring the actual evaporation from a lake. Most previous investigations of this problem have been vitiated by the fact that the investigators had no means of ascertaining what quantity of water any lake actually was losing by evaporation. Hence they could not possibly develop any reliable formula for expressing any relation between evaporation and any other quantities such as wind movement or humidity. Many formulas have been proposed but none of them are worthy of confidence because none of them ever have been checked against actual lake evaporation over a sufficiently wide range of conditions to insure their validity.

This investigation or something equivalent to it had to be the first step in the ultimate conquest of the evaporation problem and the mere fact that funds have not become available for taking the other steps which ought to follow really is nothing against the work that has been done.

If funds were available a few suitable lakes could be chosen and an investigation could be conducted now that would give reliable information regarding the behavior of these lakes under various conditions. From such information generalizations no doubt could be drawn that could be applied to other lakes. Thus by means of these generalizations evaporation from Huntington Lake or any other lake could be estimated with something like reasonable reliability.

The engineering profession either must continue in its present ignorance of this important meteorological phenomenon or it must deal with it by such methods as nature demands.

Efficient Handling of Stored Water*

Hydroelectric plants depend upon the storage of vast quantities of water, upon the uniformity of flow of the streams on which they are located or upon a combination of storage and stream flow water for their source of energy. The quality of service rendered by hydroelectric plants can be measured by the ability of the plants to carry load according to the demands of the system to which they are connected. The demand of the system, in this sense, is to replace energy from other alternate sources of higher production cost.

The efficient use of stored water is considered, first, as producing the largest possible output, and second, in the broader sense of producing an output which has the highest commercial value. Each individual plant is particularly interested in producing the largest possible output with the water available for that plant, but as this condition does not return to the plant owners always the greatest profit on plant investment it is quite evident that the handling of stored water cannot be left entirely in the hands of the plant operators. Practically all hydroelectric projects on the Pacific Coast having water storage facilities are owned by or are under control of companies having other sources of energy such as steam standby plants or interconnections with other companies. The tendency is toward further consolidation and interconnection, making the problem of efficient handling of stored water more important and more complicated.

General

The waters of the Pacific Coast as used for production of hydro-electric energy may be classified conveniently in four classes:

1. Those used as stream-flow only with no storage facilities.
2. Those used in connection with small regulating reservoirs of sufficient capacity for carrying peak loads of short duration.
3. Those used with storage facilities of sufficient capacity for accumulation of water during the light-load period of the day using same during the heavy-load period.
4. Those having full seasonal storage facilities.

About 25 per cent of the total amount developed is in each class although the present tendency is toward an increase in the class having full seasonal storage.

In the territory of the P.C.E.A. there now is developed 1,170,000 kw. in hydroelectric capacity and on the systems of those companies having hydroelectric plants there is 415,000 kw. of steam-plant capacity, a ratio of about 3 to 1. This ratio is high because in the figure of hydroelectric capacities is included irrigation districts, municipalities, etc., which have hydroelectric power only as a by-product. The average ratio of hydro to steam power for the larger companies having both sources of power is about 2 to 1.

Most of the larger hydroelectric developments constitute groups of plants in series, with the water from one principal storage reservoir used through a number of plants having small intermediate reservoirs. The Big Creek plants of the Southern California Edison Company, Fig. 1, is a characteristic group of plants thus developed.

Forecasting Water Supply

Snow Surveys—There is difference of opinion as to the value of snow surveys in forecasting probable stream flows. Two member companies are planning to make snow surveys in the future while others that have taken them in the past are discontinuing the prac-

* **Report of sub-committee.—J. W. Andree, chairman.** F. R. George, R. B. Lawton, J. F. Partridge, M. C. Wheyland, G. M. Wills.

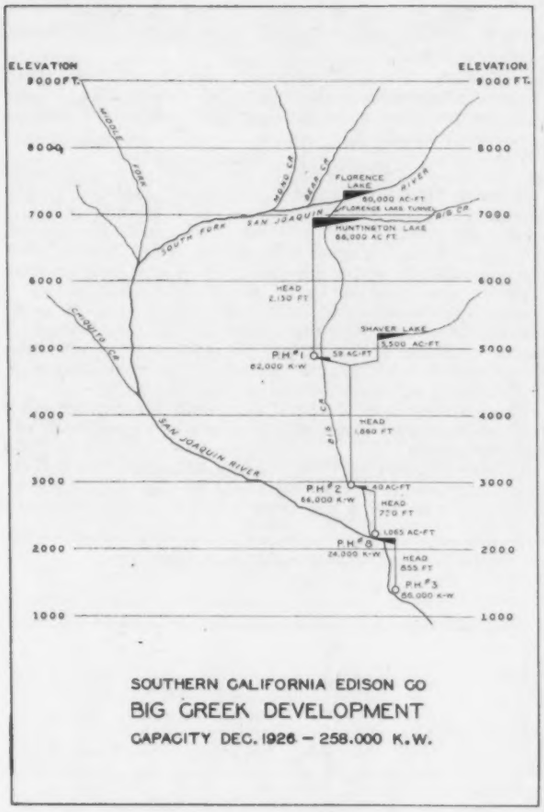


Fig. 1. Big Creek system of Southern California Edison Company.

tice as not being worth the effort required. None of the member companies depend entirely upon this kind of data for determining the probable flow of streams, but use it in conjunction with precipitation and other records. The consensus of opinion seems to be that snow surveys are not worth the effort required to make them unless the watersheds are easily accessible. The following reasons are given: (1) cost and difficulty of obtaining surveys; (2) results obtained are no more accurate than those derived from other more easily obtainable methods; (3) variation in wind velocity and direction may cause drifting of snow to such an extent that stations located to give average snow conditions for one season may give results which are radically wrong for other seasons; (4) a large portion of the water from snow which falls on exposed portions of the watershed probably melts and soaks into the ground or forms ice in the small streams and does not show up in snow surveys, but does find its way into the streams eventually.

The committee does not wish to leave the impression that snow surveys are worthless for such is not the case. Where precipitation gages are difficult or impossible to maintain, snow surveys are the next best means of determining probable run-off. Average depth of snow, its water content, age, foundation and general characteristics are factors of considerable importance in determining not only the quantity of the run-off but also its quality or the time over which the run-off will be extended. Because of the large number of factors involved in estimating from snow surveys the probable discharge of streams, considerable discretion must be used in adopting them for this purpose.

Precipitation Records—Precipitation records form the basis upon which nearly all water-supply forecasting is done. In most cases precipitation gages for obtaining such records are owned and maintained by the power companies, but in some cases use is made of government gaging stations.

There are very few drainage areas from which hydroelectric power projects receive their source of energy so fortunately situated that a single precipitation gage will record the average precipitation over the entire area. Even on watersheds of relatively small areas there usually is a considerable variation in precipitation over various portions of the area, especially if there is a wide variation of elevation. Quite naturally, as the drainage area becomes larger the value of the records from any one precipitation gage becomes less as far as stream flow estimation is concerned. Therefore it is essential that for purpose of obtaining the average precipitation on a given watershed, precipitation gages be distributed over the area and be so located that the average reading of these gages gives the average precipitation on the watershed. Due to the inaccessibility of portions of some drainage areas it is difficult to obtain precipitation records from them, especially during the winter months. In such cases the value of the record must be equated against the cost of obtaining it.

Table 1 shows the precipitation records from a single gage which is supposed to be favorably located on a relatively small drainage area of approximately 51,000 acres. This table shows that the realized run-off for the 13-year record period shown varies from 1,781.8 to 4,666.4 acre-ft. per inch of precipitation. This is a variation of from 42.1 per cent to 109.9 per cent of the actual precipitation as shown by this gage. This drainage area is largely relatively thin, decomposed granite surface with solid granite beneath and lies mostly between 7,000 and 9,000 ft. elevation. Thus there is very little moisture carried over from one season to the next and the "coefficient of wetness" may be neglected. The variation in run-off as compared with this particular precipitation gage record therefore is due to variation of precipitation over the drainage area. Precipitation gages located temporarily on other portions of this drainage area have shown this to be true.

TABLE I–Precipitation and its relation to watershed runoff.

Season	Precip. Inches	Runoff per Inch of Precip. Acre-ft.	Precip. as shown by Gauge Acre-ft.	Actual Runoff Acre-ft.	Difference Actual to Expected Acre-ft.	Ratio Actual to total Precip. per cent
1913-14	36.38	4,666.4	154,433	169,765	+15,332	109.9
1914-15	31.80	3,666.3	134,991	116,596	−18,395	86.3
1915-16	43.85	3,469.0	186,143	152,112	−34,031	81.7
1916-17	27.61	3,773.2	117,204	104,178	−13,028	88.8
1917-18	25.33	2,889.7	107,526	73,197	−34,329	68.1
1918-19	28.72	2,229.7	121,916	64,038	−57,878	52.4
1919-20	29.61	2,665.2	125,694	78,916	−46,778	62.8
1920-21	28.93	3,888.1	122,808	98,019	−24,789	79.8
1921-22	35.11	4,619.5	149,042	162,189	+13,147	108.7
1922-23	26.88	3,374.7	114,106	100,768	−13,339	88.2
1923-24	14.93	1,781.8	63,328	26,602	−36,726	42.1
1924-25	33.52	2,818.0	142,292	94,543	−47,749	66.4
1925-26	23.89	3,270.0	101,350	78,317	−23,033	78.2

When the average precipitation over a watershed is obtained comparatively accurately the results may be plotted as illustrated in Fig. 2 which is compiled from data shown in Table 1 taking only those years for which it is believed that this one gage gives records which are near the average for the whole drainage area.

In Fig. 2 the precipitation season is assumed to start Sept. 1 and end Aug. 31 of the following year. Accumulated precipitation is plotted at the end of each month and from inspection of the curve thus formed an estimate may be made of the expected run-off. It may be noted, however, that a close estimate cannot be made until April 1. The expected annual inflow scale on the right of this figure is an arbitrary scale drawn according to past records of inflow. The zero of this curve is located 3.6 above the zero of the precipitation scale as a correction for evaporation from the reservoir itself and also from the watershed as a whole. For practical purposes watershed evaporation may be assumed to be constant, but may be varied somewhat due to early or late seasonal rains.

Evaporation

Most companies on the Pacific Coast do not take evaporation into account in their estimates of power available from stored water. Usually there is at all times an inflow to reservoirs in excess of the evaporation. In nearly all cases the inflow to reservoirs is not measured directly, but is measured by gage heights in the reservoirs, hence evaporation automatically is subtracted from the inflow. Evaporation experiments conducted at Huntington Lake indicate that the total annual evaporation from this reservoir amounts to 48 in. of depth and is assumed to be distributed as shown in Table 2.

The figures in the third column of Table 2, giving the evaporation in acre-ft. are based upon the lake

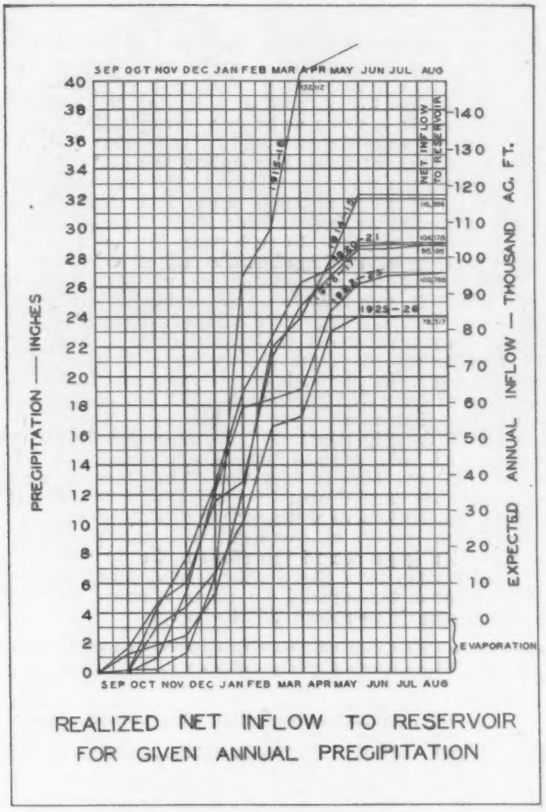

SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG
PRECIPITATION — INCHES
EXPECTED ANNUAL INFLOW — THOUSAND AC. FT.
NET INFLOW TO RESERVOIR
EVAPORATION
1925-26
REALIZED NET INFLOW TO RESERVOIR
FOR GIVEN ANNUAL PRECIPITATION

Fig. 2. Precipitation chart compiled from Table I.

being full during June and July. For other months average water levels are assumed. Total evaporation from the reservoir is equivalent to about 1.1 in. of precipitation over the entire watershed and is about 5 per cent of the reservoir capacity.

The general opinion is that evaporation may be considered a constant, that usually it is small as compared with concurrent inflow which cannot be pre-determined with accuracy, and that except in special cases the spending of much time or effort in determining this quantity with great accuracy is unwarranted. Records should be kept, however, bearing in mind a possible future use, as only continuous records over long periods are of real value.

Degree of Wetness

In the case of large watersheds where the surface is such that it absorbs large quantities of water which eventually finds its way into the streams through underground courses where the flow is more or less impeded, a portion of the precipitation of one season is carried over into the next season. This condition probably exists to some extent in all drainage areas, but very careful analysis of precipitation and flow records are necessary to determine the extent of this factor. Only one company reports the use of a "coefficient of wetness" in the determination of probable run-off and that company considers this of primary importance.

Other factors suggested as worthy of interest and further study, affecting probable inflow to reservoirs are:

1. If parallel curves are plotted continuously, one showing the actual cumualtive precipitation on a given watershed converted into run-off in acre-ft. and the other showing the actual cumulative run-off a basis would be formed for a study of run-off, coefficients of wetness, etc.

2. A study of seasonal temperatures as affecting probable distribution of seasonal run-off. Such information would be of especial value in scheduling plant construction and overhaul.

3. A study of each fall of rain, its distribution over the various subdivisions of the drainage basin and its relation to the run-off would furnish valuable information for estimating purposes.

4. The growth of irrigation and its encroachment upon vested power rights is a subject worthy of serious study.

5. The effect of adjacent large swamp areas upon evaporation, absorption of inflow and subsequent retardation of outflow is a subject of considerable interest.

Measurement of Water

Stream flow—The measurement of flow of major streams is done almost universally at gaging stations where the velocity of the water is measured by current meters and staff-gage readings are calibrated to give the quantity of water discharged. Many such gaging stations are equipped with recording gages giving a continuous record of stream flow. Most such stations are operated in conjunction with the U. S. Geological Survey. Some of the larger companies have separate departments with trained experts for operating and maintaining all such metering equipment.

Stream-flow measurement on small streams usually is done by weirs, some of which are equipped with recording gages.

Inflow to reservoirs—In nearly all cases the inflow to storage reservoirs is measured by the difference in level of the water in the reservoir over given intervals of time. In such cases the water diverted from storage is measured and the net inflow determined, neglecting evaporation, seepage, etc. In small regulating reservoirs both the inflow and outflow usually are measured.

TABLE II—Evaporation from Huntington Lake.

Month	Per Cent of Total Evaporation	Inches of Evaporation	Acre-ft. of Evaporation for Average Water Levels
Jan	3	1.44	82
Feb	4	1.92	89
March	7	3.36	120
April	10	4.80	275
May	13	6.24	750
June	14	6.72	800
July	14	6.72	800
Aug	12	5.76	685
Sept	9	4.32	480
Oct	7	3.36	340
Nov	4	1.92	170
Dec	3	1.44	113
Total	100	48.00	4704

Water in reservoirs—The quantity of water in reservoirs is determined from staff gages which indicate the depth of water. Readings from these staff gages are referred to a capacity curve or table of the reservoir which has been constructed from topography maps of the bed of the reservoir. Some such gages are of the recording type giving a continuous record of the depth of water in the reservoir.

Water Used By Various Units

For purpose of measuring water used by various units, individual meters of the Venturi type located in the penstock for each unit now are considered essential for all large and important installations. Such meters are giving satisfaction, are simple, rugged and easy of adjustment, hold adjustment fairly well and are accurate. Accuracy of this type of meter for this class of service has been established by the salt-solution velocity test. Weirs located in the tail race or in the canal ahead of the penstock have given satisfaction in the measurement of water used by an entire power station.

Meters of the orifice type have been tested and found unsatisfactory. Improvements in meters of this type eventually may produce a satisfactory meter at a much lower cost than the Venturi-type meter. Water consumption measured by the kw-hr. output of the units should be discouraged because it defeats the primary object of water measurements for individual units. The object of water measurements is to determine the performance of the unit itself with respect to the quantity of water used per unit of output, for purpose of determining wear on runners, buckets, nozzles and overall unit efficiency.

Meter calibrations—Venturi-type meters should be completely overhauled at least once a year. The recording and indicating mechanism should be checked frequently. Some companies report monthly checking with water manometer, others quarterly, and some have no set period of testing.

Operating Efficiency of Power Units

Acceptance tests—Acceptance tests are conducted on all major pieces of apparatus by most of the larger companies. Input to the prime mover is measured by a Venturi meter which has been adjusted and calibrated. Output of the generator is measured by accurate electric meters. Besides efficiency these tests show all operating characteristics from no load to maximum load, overload capacity, speed and voltage regulation, load rejection, operation of relief valves, pressure rise, governor action, and penstock pressure

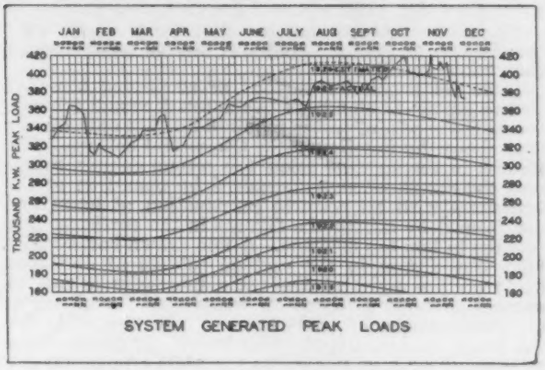


Fig. 3. Graphic method of estimating load.

and losses. Data collected is invaluable for comparison with later operating performance as well as for comparison with guaranteed performance.

For lack of testing facilities many of the smaller companies do not conduct acceptance tests, but from experience gained by the larger companies it is conceded generally that such tests should be conducted and that the information so obtained is well worth the effort expended.

Periodic efficiency tests—On units equipped with adequate testing facilities it is the general practice to make periodic efficiency tests. Such tests are made by blocking the unit at different given loads over its entire operating range, obtaining input readings on the Venturi meters and output readings on integrating wattmeters. Data obtained from these periodic tests are compared with the original acceptance test data, hence any decrease in efficiency is noted and, if possible proper steps are taken to correct the difficulty. Such tests also are of value in keeping the station operators more interested in their work, as it supplies to them information on machine performance and efficiency at various loadings. It is very desirable that the operators be allowed to assist in conducting these tests and in working up the data, because by doing this they obtain a much more lasting impression of the results than if the data merely is handed to them in finished form.

Continuous record of efficiency—Continuous records of plant efficiency are kept by almost all companies at plants equipped with adequate measuring equipment Such records usually are compiled for each day, but at some plants efficiencies are computed and posted for each shift of operators. This latter scheme serves to excite a competitive spirit among the operators, resulting in excellent operating efficiencies.

Keeping of Records

It is general practice to take readings of all powerhouse instruments every half hour. Readings on storage reservoirs, precipitation gages, etc. normally are taken once a day. Levels of water in regulating reservoirs usually are read half-hourly or hourly. Daily plant output and efficiency usually are calculated at the end of each day. All such readings usually are entered in specially prepared log books or meter books from which the daily plant report is compiled. The most important of these readings usually are wired direct to the load dispatcher's office or to sub-dispatching centers from which the data is transmitted to the general office. There it is assembled into a form ready for general distribution among company executives and engineers by the time they arrive at the office on the following morning. The written station daily reports usually are made out in triplicate, one copy retained at the plant, one by the local superintendent and the third sent to the general office files. Attached are sample forms used by the Southern California Edison Company on its Big Creek division and the Daily System Report on which this data appears in the general office on the following morning.

Generally it is conceded to be the best practice to retain all graphic meter records at the plants unless there is special occasion for wanting them sent to the general office. With many companies the stream gaging is done by other than the operating departments, in which case these records usually are retained by

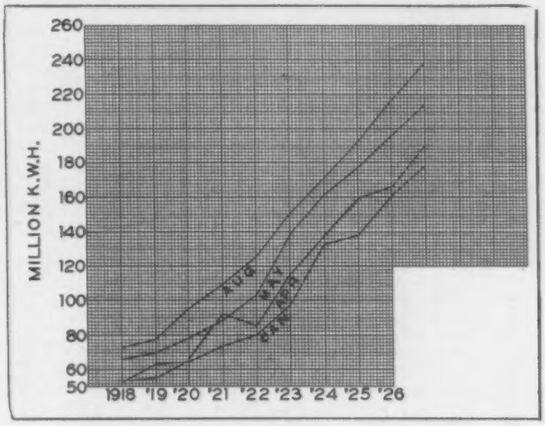
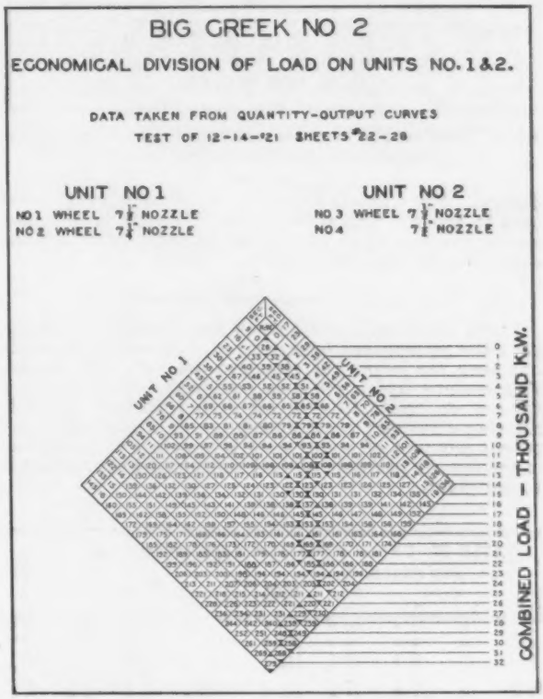


Fig. 4. Graphical presentation of kw-hr. transmitted per month.

the department having supervision over the instruments.

Most companies express station efficiency in kw-hr. per acre-ft. but kw. per sec-ft. its used by some. The former is the most logical expression to use in conjunction with stored water.

TABLE III.


BIG CREEK NO 2
ECONOMICAL DIVISION OF LOAD ON UNITS NO. 1 & 2.
DATA TAKEN FROM QUANTITY-OUTPUT CURVES
TEST OF 12-14-'21 SHEETS 22-28
UNIT NO 1
NO 1 WHEEL 7½ NOZZLE
NO 2 WHEEL 7½ NOZZLE
UNIT NO 2
NO 3 WHEEL 7½ NOZZLE
NO 4 7½ NOZZLE
UNIT NO 1
UNIT NO 2
COMBINED LOAD — THOUSAND K.W.

Forecasting of System Load

Almost every company reporting has different methods of estimating future load, but generally use some system based upon a percentage increase over loads of past years. For estimating future loads in kw. Fig. 3 shows a graphic method used by one of the larger companies which has proved satisfactory. By reference to this curve not only the load estimate is seen but the probability of variation from the estimate also is ap-

parent. A curve of this kind which is kept up continuously also is of great help in re-estimating loads for the immediate future. Actual peak loads may vary about 10 or 15 per cent above or below the average but these variations are due to conditions that cannot be foreseen. With a series of such curves drawn a percentage increase for each month may be established easily and a curve of peaks for the following year

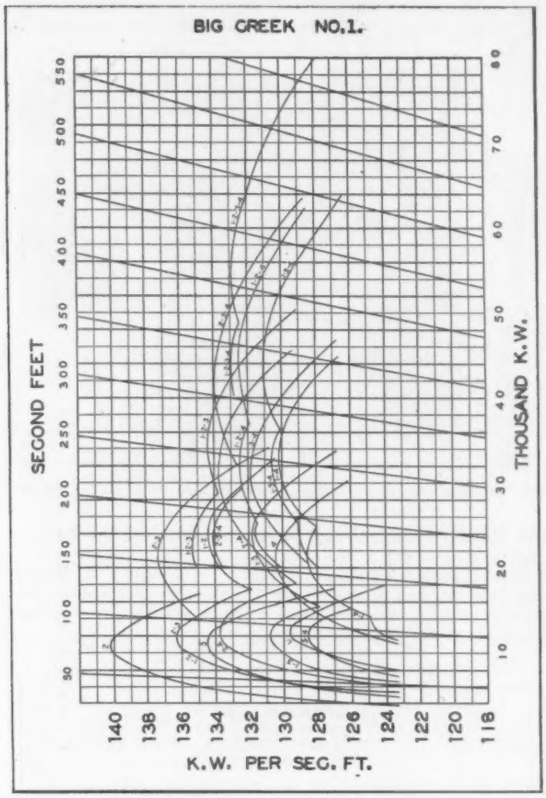


Fig. 5. Useful form of operating information. Individual-unit and combined-unit operating-efficiency curves.

derived. Fig 4 shows a method for obtaining estimated load in kw-hr. The curve for each month is extended on the average slope of the line in order to obtain the load estimate for the following year.

Economical Operation of Hydro Plants

There has been an erroneous assumption that in the past the economical operation of hydroelectric plants has been far below the standard set by steam plants. The modern hydro plant is equipped with measuring devices sufficient to give all data necessary for calculating efficiency continuously and in these plants the output per unit of water used is watched as closely as is the output per unit of fuel consumed in the modern steam plant.

While there may be a little more technical knowledge required for operation of the modern steam plant this work usually is done by a few specialists and the general intelligence required to operate the modern hydro plant is as high as that required for the steam plant.

Division of Load Between Units in a Plant

For determination of the most efficient combination of units in a plant the best practice seems to be periodic testing of each unit throughout its operating range and assembling this test data in tabular and curve form for each unit and for each combination of units. From these curves or tables the most economical division of load between the various units may be determined readily.

Table III shows the method of combining the olad on two units. Each square in the top diagonal columns shows the sec-ft. of water required by that unit for the load shown by the figures in the second column. The figures in the squares below the second column represent the sec-ft. of water required by operation of the two untis with all possible combination of loads and are formed by adding the figures in the corresponding squares in two top columns. A line drawn horizontally from any figure in the vertical column of combined loads on the right of the table intersects a row of squares containing figures of water used for all possible combinations of loads between the two units for the given combined load. The lowest figures in these intersected squares represents the most economical use of water and following the columns up to the right and up to the left the proper loading for each unit may be determined easily.

Tables such as Table IV and curves similar to Fig. 5, are constructed from tables such as Table III. These show the most economical combinations of load for the entire plant in a convenient form for use of the operators. For a load of from 0 to 16,000 kw., from the curve on Fig. 5, No. 2 unit only would be operated. For a load of from 16,000 kw. to 30,000 kw. units 2 and 3, etc. From a table similar to Table IV the proper division of load between units may be determined readily.

Division of Load Between Hydro Plants Using Stored Water

Division of load between hydro plants using stored water is fixed usually by plant capacities, capacities of forebays or intermediate reservoirs. amount of water to be used, load requirements, etc. However, in cases where there is any choice, the method used for determination of economical division of loads between the various units in one plant also may be applied to a system of plants, considering each plant as a unit. In this case, however, efficiencies must be relative and must be worked out on a percentage basis due to the difference in the power-producing value of a unit of water in the various plants. The regulation of water in intermediate reservoirs of a chain of plants is a problem seriously affecting the economical division of load between plants. Unforunately many such plants are provided with inadequate storage capacity and the necessity of maintaining high levels for the sake of efficiency and for pulling peak loads seriously affects economical division of load.

Close co-operation between load dispatchers, water dispatchers and plant operators is necessary in such cases to obtain the greatest output for a given quan-

TABLE IV—Division of load between different units.

BIG CREEK 2					BIG CREEK 2						BIG CREEK 2						
Load	Units		Sec.	K.W.	Load	Units on Line			Sec.	K.W.	Load	Units on line				Sec.	K.W.
M.W.	1	2	Ft.	S.F.	M.W.	1	2	3	Ft.	S.F.	M.W.	1	2	3	4	Ft.	S.F.
2.0	0	2.0	19.9	85.4	20.0	0	12.0	8.0	163.1	120.8	32.0	8.0	8.0	8.0	8.0	265.0	120.8
4.0	0	4.0	34.9	106.0	22.0	7.0	8.0	7.0	181.4	121.3	34.0	8.0	10.0	8.0	8.0	280.8	121.1
6.0	0	6.0	50.1	113.8	24.0	8.0	8.0	8.0	197.2	121.7	36.0	9.0	10.0	8.0	9.0	297.0	121.2
8.0	0	8.0	65.6	117.4	26.0	8.0	10.0	8.0	213.0	122.1	38.0	9.0	11.0	8.0	10.0	313.2	121.3
10.0	0	10.0	81.4	119.2	28.0	9.0	11.0	8.0	229.2	122.2	40.0	9.0	12.0	9.0	10.0	329.7	121.3
12.0	0	12.0	97.7	119.8	30.0	9.0	12.0	9.0	245.7	122.1	42.0	10.0	12.0	9.0	11.0	346.5	121.2
14.0	7.0	7.0	116.1	120.6	32.0	10.0	13.0	9.0	262.6	121.9	44.0	11.0	13.0	9.0	11.0	363.5	121.0
16.0	8.0	8.0	131.8	121.4	34.0	11.0	13.0	10.0	279.8	121.5	46.0	12.0	13.0	10.0	11.0	381.0	120.7
18.0	8.0	10.0	147.6	122.0	36.0	12.0	14.0	10.0	297.4	121.0	48.0	12.0	14.0	10.0	12.0	398.6	120.4
20.0	9.0	11.0	163.8	122.1	38.0	14.0	14.0	10.0	315.6	120.4	50.0	13.0	14.0	10.0	13.0	416.8	120.0
22.0	10.0	12.0	180.4	122.0	40.0	14.0	15.0	11.0	334.5	119.5	52.0	14.0	14.0	11.0	13.0	435.4	119.5
24.0	11.0	13.0	197.4	121.6	42.0	15.0	15.0	12.0	354.0	118.6	54.0	14.0	15.0	11.0	14.0	454.3	118.9
26.0	12.0	14.0	215.0	120.9	44.0	16.0	16.0	12.0	375.1	117.3	56.0	15.0	15.0	11.0	15.0	473.8	118.2
28.0	14.0	14.0	233.2	120.1	46.0	16.0	16.0	14.0	397.7	115.7	58.0	15.0	15.0	12.0	16.0	493.9	117.4
30.0	15.0	15.0	252.5	118.8	48.0	16.0	16.0	16.0	428.6	112.0	60.0	16.0	16.0	12.0	16.0	515.0	116.5
32.0	16.0	16.0	273.6	117.0							62.0	16.0	16.0	13.0	17.0	537.1	115.4
											64.0	16.0	16.0	15.0	17.0	562.5	113.8
											65.0	16.0	16.0	16.0	17.0	579.6	112.1

tity of water and best service conditions from such plants.

Division of Load Between Steam and Hydro Plants

With the total system load, the hydro power available, and the steam load determined, there remains still the problem of dividing the load between the steam plants and hydro plants to obtain the greatest overall economical operating conditions. In this is involved the efficiencies of the various generating units, loading of transmission lines, variation in cost of fuel and reliability of service.

Some companies consider reliability of service to certain classes of load of such importance that they carry a predetermined portion of their load on steam plants even at times when there is actually available water power which is going to waste. Other companies use steam plants only in case of shortage of water or in case of extreme emergency. The matter of service is a problem to be solved by each company to meet the requirements peculiar to its system and load. The increasing reliability of long-distance transmission lines is having a tendency toward placing more dependence upon them than has been considered safe practice in the past. It is the general practice on the Pacific Coast to determine the kw-hr. steam power required as far in advance as possible and then to distribute this steam load so that the largest possible amount of it may be generated on the most efficient units and at times when the cheapest fuel is available.

The problem of economical division of load between steam and hydro plants may be solved in a manner similar to that described for the units in a single plant or a group of plants. In this case the storage hydro plants are considered as one group and the steam plants as the other group, each group being assumed to be operated in its most efficient manner. In making this comparison it is necessary to reduce efficiencies of both groups of plants to the same unit basis. The loss in kw. above the most economical point of operation for each group of plants is a convenient unit to use. The lowest loss on transmission for each group is at no load, but when combined with plant losses the point of minimum loss is well above the no-load point.

This may be a laborious process of solution, but the savings in losses that may be effected are much greater than the average operator would assume and the results obtained are well worth the effort put forth in obtaining the solution.

The Southern California Edison Company is giving an increasing amount of attention to the economical division of load with results as indicated in Table V for the year 1925 and 1926 which were rather similar in amount of storage water available.

Inspection of the figures in Table V shows a considerable increase in plant efficiency for all plants except Big Creek 2. There is some doubt as to the accuracy of the meter readings during the last four months of 1925 which may account for the apparent decrease in efficiency. The net savings represented by the figures of this table represent about 15,000,000 kw-hr. annually, a figure well worth working for.

TABLE V—Comparative plant efficiencies 1925-1926, Southern California Edison Company.

	Big Creek 1				Big Creek 2				Big Creek 3				Big Creek 8			
	Kw.-hr. Generated		Kw.-hr. per Acre-ft.		Kw.-hr. Generated		Kw.-hr. per Acre-ft.		Kw.-hr. Generated		Kw.-hr. per Acre-ft.		Kw.-hr. Generated		Kw.-hr per Acre-ft.	
	1925	1926	1925	1926	1925	1926	1925	1926	1925	1926	1925	1926	1925	1926	1925	1926
Jan.	5,841,000	17,218,000	1,448	1,574	6,655,000	15,675,000	1,324	1,398	16,848,000	15,096,000	647	653	2,831,000	6,818,000	547	590
Feb.	1,904,000	18,376,000	1,366	1,563	12,565,000	19,828,000	1,351	1,393	39,917,000	29,666,000	641	657	5,499,000	4,696,000	563	606
March	8,696,000	21,461,000	1,497	1,548	14,628,000	24,801,000	1,346	1,364	52,678,000	53,644,000	668	662	6,158,000	6,862,000	556	583
April	15,206,000	16,272,000	1,511	1,551	27,583,000	30,610,000	1,357	1,356	46,986,000	47,783,000	668	669	11,966,000	12,472,000	581	590
May	20,562,000	31,968,000	1,558	1,600	35,132,000	36,046,000	1,367	1,343	47,455,000	54,281,000	677	688	14,852,000	12,922,000	585	581
June	29,956,000	41,514,000	1,596	1,607	31,170,000	36,169,000	1,374	1,348	48,551,000	56,360,000	686	667	13,974,000	15,655,000	581	585
July	43,117,000	31,898,000	1,588	1,618	34,953,000	31,063,000	1,377	1,393	50,804,000	34,844,000	690	685	15,646,000	13,386,000	585	595
Aug.	39,395,000	38,478,000	1,593	1,597	28,970,000	33,289,000	1,387	1,357	35,721,000	22,089,000	679	682	12,030,000	14,271,000	583	594
Sept.	32,255,000	36,609,000	1,600	1,606	28,536,000	31,440,000	1,408	1,358	20,757,000	18,634,000	666	681	12,038,000	13,433,000	590	591
Oct.	26,139,000	30,727,000	1,619	1,618	23,620,000	26,636,000	1,421	1,370	21,399,000	17,045,000	662	685	8,170,000	11,353,000	581	593
Nov.	26,645,000	20,860,000	1,596	1,596	25,873,000	19,428,000	1,423	1,387	20,667,000	25,647,000	660	669	10,642,000	8,501,000	590	586
Dec.	26,237,000	32,204,000	1,580	1,586	23,629,000	30,434,000	1,395	1,380	22,169,000	36,639,000	666	677	10,049,000	13,033,000	587	591
Avg.	22,996,000	28,140,000	1,546	1,589	24,443,000	27,951,000	1,377	1,371	35,329,000	31,706,000	667	673	10,049,000	11,117,000	577	590

System Speed Regulation

When there is any choice between the operation of steam turbines, hydraulic turbines and impulse water wheels for system speed regulation or for varying load it is advisable usually to carry this varying load on the impulse-waterwheel units because of their high relative efficiency throughout a wide range of load. Steam and hydraulic turbine-driven units may be given an economical block load.

Water Dispatching

Water dispatching in most companies is handled by the load dispatchers, but some of the larger companies have water dispatchers located in close proximity to the water-power plants. It is the duty of these water dispatchers to arrange for the most economical carrying of the load assigned to plants under their jurisdiction. The water dispatcher is responsible for the economical division of load between the units of each plant and between the various plants in his division, co-operates with the load dispatcher in obtaining proper loading for his plants and furnishes the load dispatcher with such data as may be desired regarding the operation of the hydro plants.

The water dispatcher also collects all data which may be of value to him in the performance of his duties, such as plant efficiencies, unit efficiencies, stream flows, weather conditions, etc. These men depend upon telephone communication between the various plants for obtaining the necessary operating data. An ideal situation would be to have long-distance water-level and load indicators from all plants centrally located in the water dispatcher's office.

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Meter Committee Reports[1]

Special Tests and Investigations on Meters and Allied Equipment*

Activities of the recently instituted subcommittee appointed to investigate the subjects of interest to the meter committee, but more or less remote from meters and metering appurtenances, have been limited to the investigation of a few problems that have presented themselves to the subcommittee.

In submitting this and any subsequent report it is hoped that the variety and nature of the data contained will stimulate the interest of all members of the meter committee to such a point that the succeeding subcommittees may act as a clearing house for the ideas, problems and solution of the future.

Combination Torsion-Head and Indicating Wattmeter

The ordinary dynamometer-type wattmeter has several inherent errors which must be taken into account when making accurate measurements. Among these is that caused by the mutual inductance between the moving or potential coil and the stationary or current coil of the wattmeter. When current is allowed to flow in the potential coil it sets up a slight potential in the current coil due to this mutual inductance which causes a current to flow. This induced voltage according to the impedance of the whole circuit, adds to or subtracts from the load current under measurement and causes an error in reading. Where the impedance of the external current circuit is high this error is negligible, but where the current coil is connected to a shunt or current-transformer secondary, or other low-impedance circuit it may cause an appreciable error. The greatest error due to this cause occurs when the pointer is at zero and at maximum positions on the scale.

Mutual inductance between these two coils is at its maximum when the coils are parallel and is zero when they are at right-angles. In most modern wattmeters this right-angle position occurs at the middle position on the scale. This error thus can be eliminated by keeping the moving coil always in the position of zero mutual inductance. As an illustration of the possible errors that may exist in various types of wattmeters Table I is submitted.

TABLE I—Possible errors due to mutual inductance with normal potential applied.

Type Wattmeter	Range Amps.	Volts	Watts	Possible Error Watts	Per Cent Full Scale
G. E. P-4	5.0	150	500	4.0	0.8
Weston, 310	5.0	150	750	1.5	0.2
Weston 310, Form 2	0.1	150	3.0	0.054	1.8

When small deflections of from 3 to 8 divisions are being read the per cent error may be as much as 10 to 20 times the per cent values given in Table I.

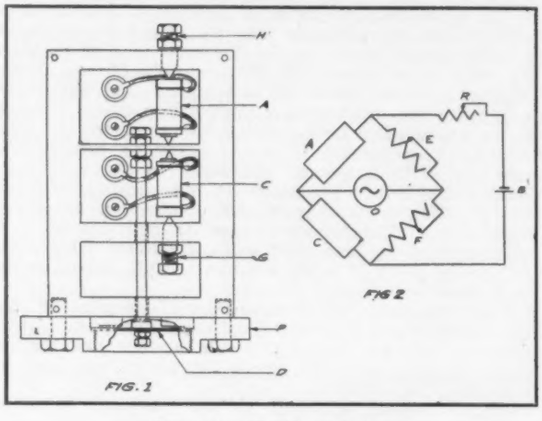
Recognizing that this error may be grave in certain measurements one of the Pacific Coast utility laboratories has developed a torsion-head which when applied to wattmeters of the dynamometer type entirely eliminates this error. It consists of a revolvable pointer and thumb-nut fastened in the top of the bakelite cover of the meter whose axis of rotation is in line with the axis of the moving coil. To this device is fastened the end of the movement spring which ordinarily would be fastened to the frame of the instrument. The indicating pointer holds a zero position in the center of the scale, in which case the moving coil is in the position of zero mutual inductance. When current is applied the indicating pointer tends to deflect one way or another and the operator revolves the torsion pointer. This manually applied torque on the spring causes the indicating pointer to return to zero, then the reading of watts is obtained by reading the deflection of the torsion pointer over a specially calibrated scale.

Some of the advantages of the torsion-head wattmeter are:

1. The torsion scale is perfectly uniform over its entire range.
2. Plus and minus readings can be read without reversing the potential. This is an advantage in certain cases where the wattmeter is used as a differential detector, such as in the Silsbee deflector method of calibrating current transformers.
3. The error due to mutual inductance is entirely eliminated.
4. The wattmeter may be used as an indicating instrument, either as a center zero or left-hand zero, merely by setting the torsion pointer at the corresponding zero. (The use of the left-hand zero can be made in this way only if the instrument has a single torsion spring as in the G.E. P-4 and other similar instruments.)
5. The instrument is much more easily operated than other types of torsion-head dynamometers because the deflection of the indicating pointer is not restricted to a small part of the scale. Large changes in reading are more easily noticed and very quickly compensated for.

Penstock Vibration Recorder

In recording surges and water hammer in pipes and penstocks it is necessary to have a recording element with a very small time lag. For this purpose the ordinary electric oscillograph is an ideal recorder. The oscillograph requires, however, a mechanical-electrical link which will reproduce faithfully and accurately the hydraulic pressure variations in terms of electrical impulses for recording on the oscillograph.



Figs. 1, 2. Vibration recorder.

To do this, there was designed in one of the Pacific Coast Utility laboratories a vibration recorder which is described here. This instrument employs two carbon piles in a manner similar to that used in a Bureau of Standards vibration recorder described in Technologic Paper No. 247 of the U. S. Bureau of Standards.

The recorder is built up out of a singel block of steel machined as shown in Fig. 1. The diaphragm D is connected in the penstock or pipe system by means of pipe fittings and transmits the pressure variations to a thin steel web W. The movement of this web causes the pressure on the two carbon piles A and C to increase and decrease atlernately thereby changing the electrical resistance of these piles accordingly. The

[1] **A. J. Hall,** Ontario Power Company, chairman. **W. N. Lindblad,** Pacific Gas and Electric Company, vice-chairman. **The California Oregon Power Company:** S. M. Bullis, F. D. Emory. **Duncan Electric Manufacturing Company:** A. F. Blecksmith. **General Electric Company:** G. P. MacKenzie, W. C. Smith. **Great Western Power Company:** W. G. Knight. **Los Angeles Bureau of Power & Light:** J. C. Alberts. **Los Angeles Gas & Electric Corporation:** W. A. McMeekin. **Midland Counties Public Service Corporation:** D. D. Smalley. **Ontario Power Company:** W. Hastings. **Pacific Gas and Electric Company:** R. Crowell, O. A. Knopp. G. H. Searle. **San Diego Consolidated Gas & Electric Company:** C. Goldcamp. T. P. Garett. W. H. Talbott. **Sangamo Electric Company:** J. G. Monahan, L. A. Nott. **San Joaquin Light & Power Corporation:** G. A. Collins, C. F. Gilcrest, M. C. Mitchell. **Southern California Edison Company:** L. H. Beebe, L. L. Conrad, E. Ealson, W. R. Frampton, A. S. Price, F. A. Redding, J. H. Vivian. **The Southern Sierras Power Company:** R. G. Jones. **The States Company:** H. M. Thomas. **Western States Gas & Electric Company:** J. C. Abel. **Westinghouse Electric & Manufacturing Company:** J. E. Bridges, W. F. Grimes.

* **Report of sub-committee.**—L. L. Conrad, chairman. W. N. Lindblad.

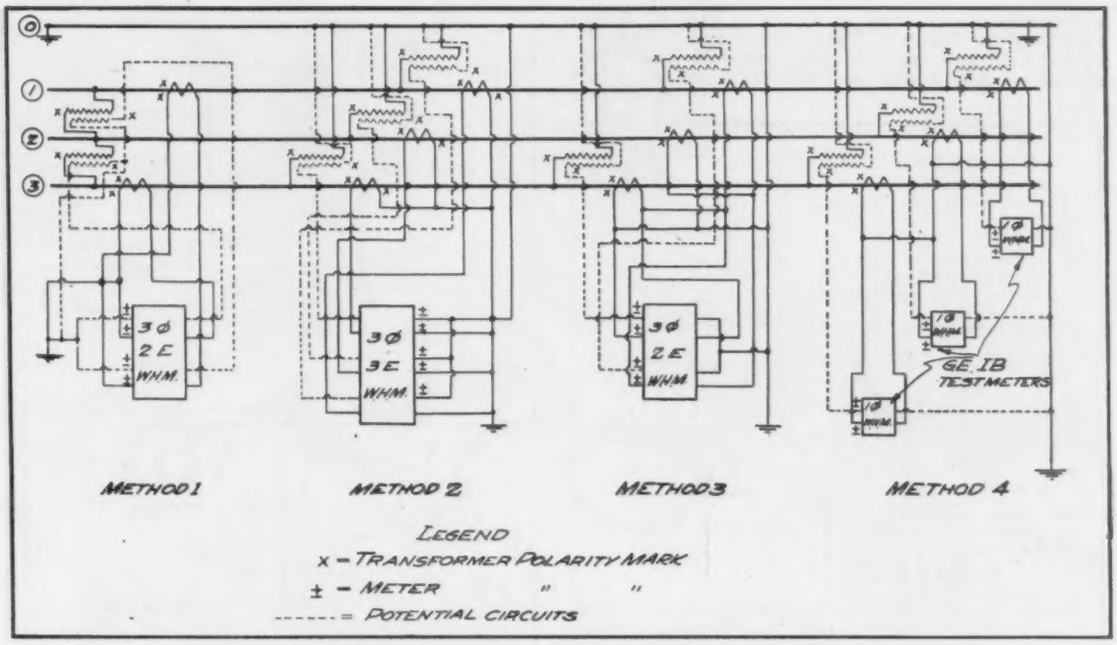


Fig. 3. Four-kilovolt test connections for 3-phase, 4-wire metering investigation.

two carbon piles are connected in a bridge circuit as shown in Fig. 2 where A and C are the two carbon piles, E and F two adjustable rheostats, O the oscillograph element and B a battery.

In operation the diaphragm is connected in the penstock and the oscillograph battery and rheostats connected as shown. The rheostats E and F are adjusted to give an average current of zero on the oscillograph element and the rheostat R adjusted to give proper amplitude to the pulsating current on the oscillograph mirror. The picture or record then is taken. The apparatus may be calibrated for a given rheostat setting by applying to the diaphragm a non-pulsating pressure of known value and observing the deflection of the oscillograph. Adjusting screws G and H are used for equalizing the pressure on the two carbon piles.

The report of the 1925-26 hydraulic power committee N.E.L.A. describes tests made in the field utilizing this apparatus.

Three-Phase, Four-Wire Metering Methods

Problems involved in the metering of 3-phase, 4-wire power circuits are numerous and of varied nature. The following reports of investigations on this subject are incomplete and do not include some of the very important variables that should be covered in detail.

The metering of power delivered at 4000 kv. over a circuit of three line wires and one grounded neutral from a star-connected bank of transformers has caused some discussion as to the proper method to be employed. Various metering schemes have been investigated, leading to as many different conclusions according to the variables of connections and load conditions. In this report only two of the most common methods will be considered and only under conditions of balanced load and unbalanced voltages.

Object and Method of Test

To determine the discrepancy in the accuracy of registration between two methods commonly empolyed is the object of this test. An experimental circuit was built up in the standardizing laboratory consisting of an isolated 4-kv. 3-phase, 4-wire line in which were connected the necessary instrument transformers, watthour meters and instruments enabling the measurement of power by four different methods. Load control and voltage regulation was obtained by the use of regulators, resistances, transformers and motors as conditions required.

Method 1—Refer to Fig. 3. Two-element watthour meters with two line-current elements, and two line-to-line potential elements. Used as a check meter under conditions of balanced load, or, no currnet in lineO.

Method 2. Under investigation—Three-element watthour meters with three line-current elements, and three line-to-neutral potential elements.

Method 3. Under investigation—Two-element watthour meters with two current-elements connected to three detla-connected current-transformer secondaries and two line-to-neutral potential elements.

Method 4. Considered as a standard—Three single-phase induction test meters each connected with a line-current element and a line-to-neutral potential element. Kept at a constant temperature of 35 deg. C. in a thermostatically controlled temperature box. Preparatory to the investigation at 4-kv. the errors of all instruments and instrument transformers were determined and found to be less than 0.5 per cent plus or minus for any combination of meter and transformers.

Procedure of Test. After a definite load point and voltage condition was obtained the registration of methods No. 2 and No. 3 were compared separately against method No. 4.

TABLE II—Results of tests of Method 4.

Test No. 1—Conditions: System of 1.0 power factor, 40 per cent load balanced

Condition of Voltage	Error in Per Cent Method No. 2	Method No. 3	Discrepancy
Balanced	0.54+	0.55+	0.01
1-0, = 5 per cent high	0.75+	0.76+	0.01
1-0, = 10 per cent high	1.00+	1.10+	0.10
2-0, = 5 per cent high	0.81+	0.65+	0.16
2-0, = 10 per cent high	0.50+	0.80+	0.30

Test No. 2—Conditions: System at 0.90 power factor, current lagging, 40 per cent load balanced

Condition of Voltage	Error in Per Cent Method No. 2	Method No. 3	Discrepancy
Balanced	0.37+	0.45+	0.08
1-0, = 10 per cent high	0.75+	0.65+	0.10

Test No. 3—Conditions: System at 0.30 power factor, current lagging, 40 per cent load balanced

Condition of Voltage	Error in Per Cent Method No. 2	Method No. 3	Discrepancy
2-0, = 5 per cent low	1.46+	1.83+	0.37
2-0, = 10 per cent low	1.35+	0.91+	0.44

Effect of Ungrounded Potential Neutral Upon Watthour Meters

The object of this test was to determine the effect on watthour-meter registration of ungrounded potential transformer neutral in a 4-wire star installation. The metering installation selected for test, meters a bank of power transformers connected Y-Delta and supplying a pump load of approximately 500 kv. at 440 volts from a 4/2.3-kv. Delta-Y source. The primary neutral of the power transformers was ungrounded. Three potential transformers were used with neutral

ungrounded for the test as shown in Fig. 4. Meters used were the standard Westinghouse and G.E. 4-wire meters with two potential coils and with the middle current element wound on both upper and lower cur-

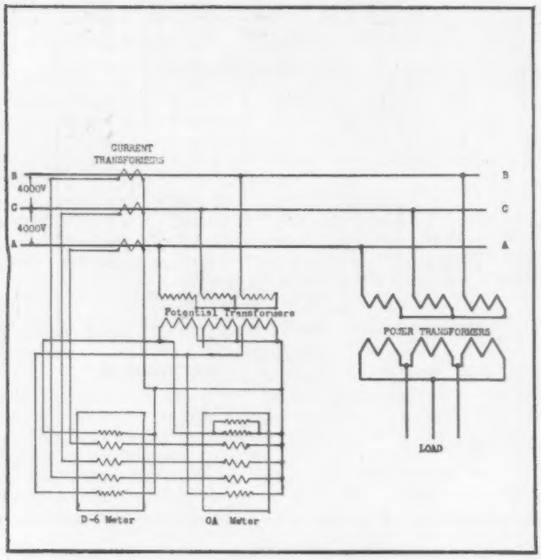


Fig. 4. Metering installation at a water company's plant.

rent-coil laminations. Both meters had demand registers.

The following instruments were used in the test in addition to the Watthour and demand meters:

1 Warren Motor (Telechron) clock.
1 G.E. P-3 voltmeter, 150-300 volts.
1 Westinghouse core-loss voltmeter, 150 volts.
1 Reed type frequency meter.
1 General Radio Company string oscillograph.
1 Weston model 310 wattmeter.

Test Methods and Results

Test No. 1. A warren motor "Telechron" clock was connected to the potential transformer secondaries, neutral ungrounded, and the normal loads of two watthour meters and demand meters connected. This clock then was compared over several hours running against a good pocket watch with the following results:

From 11:21 a.m. to 12:21 p.m. (1 hr.) Warren clock ½ min. slow.

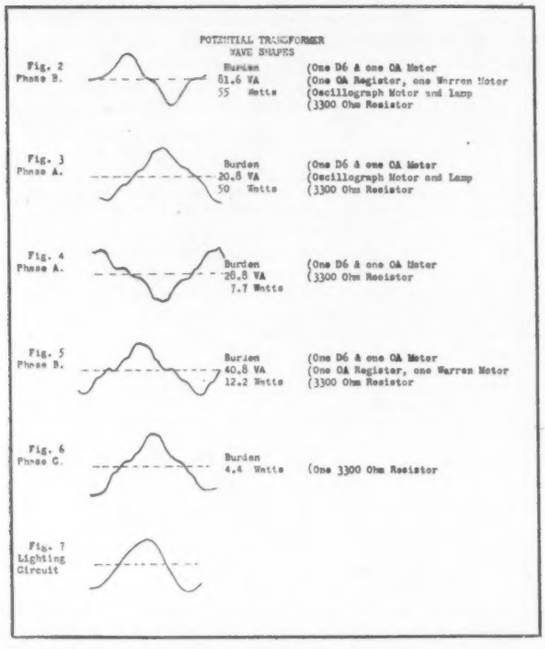

POTENTIAL TRANSFORMER WAVE SHAPES
Fig. 2 Phase B.
Burden 81.6 VA 55 Watts
(One D6 & one OA Meter (One OA Register, one Warren Motor (Oscillograph Motor and Lamp (3300 Ohm Resistor
Fig. 3 Phase A.
Burden 20.8 VA 50 Watts
(One D6 & one OA Meter (Oscillograph Motor and Lamp (3300 Ohm Resistor
Fig. 4 Phase A.
Burden 20.8 VA 7.7 Watts
(One D6 & one OA Meter (3300 Ohm Resistor
Fig. 5 Phase B.
Burden 40.8 VA 12.2 Watts
(One D6 & one OA Meter (One OA Register, one Warren Motor (3300 Ohm Resistor
Fig. 6 Phase C.
Burden 4.4 Watts
(One 3300 Ohm Resistor
Fig. 7 Lighting Circuit

Fig. 5. Potential transformer wave shapes; metering installation of Fig. 4.

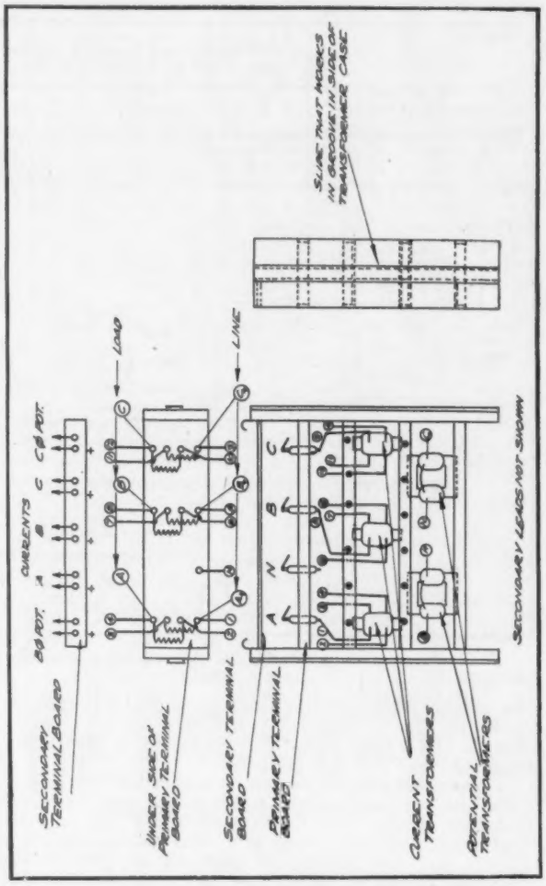


Fig. 6. Weatherproof metering transformer equipment, Packard Electric Company, 3-phase, 4-wire.

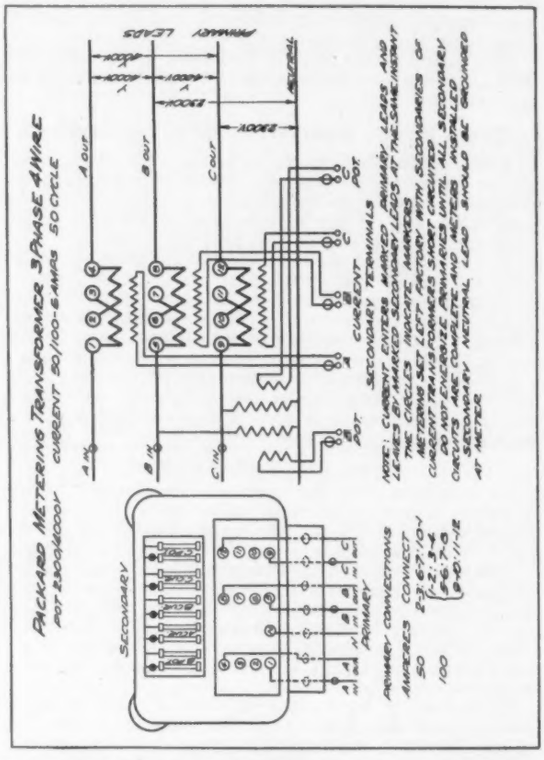


Fig. 7. Application of Packard metering equipment to 3-phase, 4-wire service.

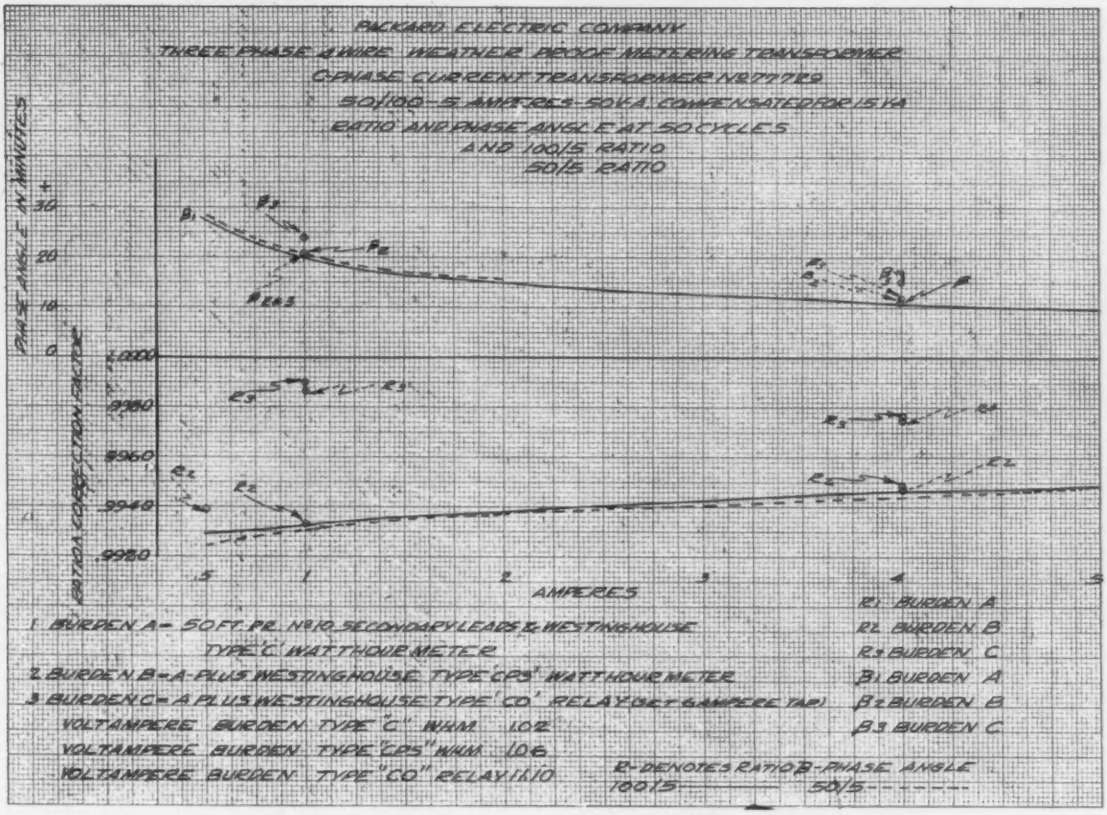

PACKARD ELECTRIC COMPANY
THREE PHASE 4 WIRE WEATHER PROOF METERING TRANSFORMER
CPHASE CURRENT TRANSFORMER NR 7729
50/100-5 AMPERES-50 K.A. COMPENSATED FOR 15 K.A.
RATIO AND PHASE ANGLE AT 50 CYCLES
AND 100/5 RATIO
50/5 RATIO
PHASE ANGLE IN MINUTES
RATIO CORRECTION FACTOR
AMPERES
1 BURDEN A - 50 FT. PR. NO 10 SECONDARY LEADS & WESTINGHOUSE TYPE 'C' WATTHOUR METER
2 BURDEN B - A PLUS WESTINGHOUSE TYPE 'CPS' WATTHOUR METER
3 BURDEN C - A PLUS WESTINGHOUSE TYPE 'CO' RELAY (SET @ AMPERE TAP)
VOLTAMPERE BURDEN TYPE 'C' WHM 10.2
VOLTAMPERE BURDEN TYPE 'CPS' WHM 10.6
VOLTAMPERE BURDEN TYPE 'CO' RELAY 1.1.10
R1 BURDEN A
R2 BURDEN B
R3 BURDEN C
B1 BURDEN A
B2 BURDEN B
B3 BURDEN C
R-DENOTES RATIO B-PHASE ANGLE
100/5 ———— 50/5 - - - - - -

Fig. 8. Test curves on current transformer.

From 11:21 a.m. to 1:50 p.m. (2 hr., 29 min.) Warren clock O.K. (Note: At 60-cycle frequency Warren clock should give accurate time.)

Test No. 2. To determine the effect on induction apparatus the readings of the core-loss voltmeter were compared against the dynamometer voltmeter when both were connected to the secondaries of each of the three potential transformers. (Note: On a sine wave potential both of these voltmeters should read alike. On any other wave shape the dynamometer type voltmeter will indicate the effective voltage while the core-loss voltmeter will indicate the equivalent effective sine voltage.) The following results were obtained:

Phase	Voltage Dynamometer	Voltage Core-Loss	Voltage Dynamometer	Voltage Core-Loss
A	95.0	84.0	112.8	112.2
B	96.0	85.5	114.0	113.0
C	111.0	97.4	112.0	111.3

Test No. 3. The system frequency was measured on the secondaries of each of the three transformers with the neutral ungrounded:

Phase	Frequency Cycles
A	60.1
B	60.1
C	60.1

No other reeds than that corresponding to 60.1 cycles, vibrated.

Test No. 4. Using the General Radio oscillograph the wave shape of potentials on the secondaries of the potential transformers were traced as shown in Fig. 5. The wave shape of the lighting circuit, which is obtained from the same primary source through the transformer bank, was traced as shown. Apparently the distorted wave shapes obtained were due to the fact that the potential transformers were connected Y-Y with the burden unequally divided and the neutral ungrounded.

Test No. 5. The neutral was temporarily grounded and the wave shape again noticed. In this case the wave showed almost a true sine wave.

Test No. 6. The accuracy of the G.E. D-6 meter itself, without reference to the installation as a whole, was determined by connecting the dynamometer type wattmeter directly in series with it on consumer's load. (Neutral of potential transformers ungrounded.) The following results were obtained:

Average Watts	Revolutions	Time	Correction Factor
463	8	62.2	1.00

Test No. 7. The accuracy of testing the meter under these conditions was determined by actually testing it with the dynamometer wattmeter and a phantom load such as is used in regular meter testing. The supply was obtained from the secondaries of the potential transformers with neutral ungrounded.

Average Watts	Revolutions	Time (Sec.)	Correction Factor
516.5	8	56.3	1.01

Test No. 8. The same meter was tested in a similar manner using the lighting circuit as a supply for the phantom load. Then:

Average Watts	Revolutions	Time	Correction Factor
500.3	8	57.6	1.00

Test No. 9. A G.E. type M-10 synchronous demand register was connected to the potential transformer secondaries and the speed measured both by timing and stroboscopically. This test showed that the speed of the timing motor varied, at times being in step and at other times being 4 or 5 per cent fast.

Test No. 10. The balance of voltages in the secondaries of the potential transformers with the watthour meters connected was measured by the dynamometer type voltmeter. These showed:

Phase	Neutral Ungrounded	Neutral Grounded
A	116.0	113.5
B	117.2	114.5
C	136.0	112.0

Test No. 11. The load at this station was very steady. Therefore it was possible by alternately grounding and ungrounding the potential transformer neutral to get the difference in registration for the two conditions. This result is the actual difference in registration caused by the combined effect of poor wave shape and the distortion of the metering potentials due to the ungrounded neutral:

Neutral Floating Rev.	Time (Sec.)	Kw.	Neutral Grounded Rev.	Time (Sec.)	Kw.	C.F.
15	58.2	395.8	15	49.4	466.4	1.178
15	57.6	400.0	15	49.6	464.5	1.161
				Average	C.F.	1.169

The above test was made with one G.E. D-6 watthour meter and one Westinghouse OA watthour meter and one OA demand register connected to the potential transformers. The error would vary if more or less apparatus were connected.

Conclusions

1. The Warren synchronous motor is not appreciably affected by distortion of wave shape.

2. Distortion of wave shape caused a great discrepancy in measurement with the core-loss voltmeter. This would indicate a large reading error in induction apparatus such as induction voltmeters, induction timing meters, etc.

3. The reed type of frequency was not affected appreciably.

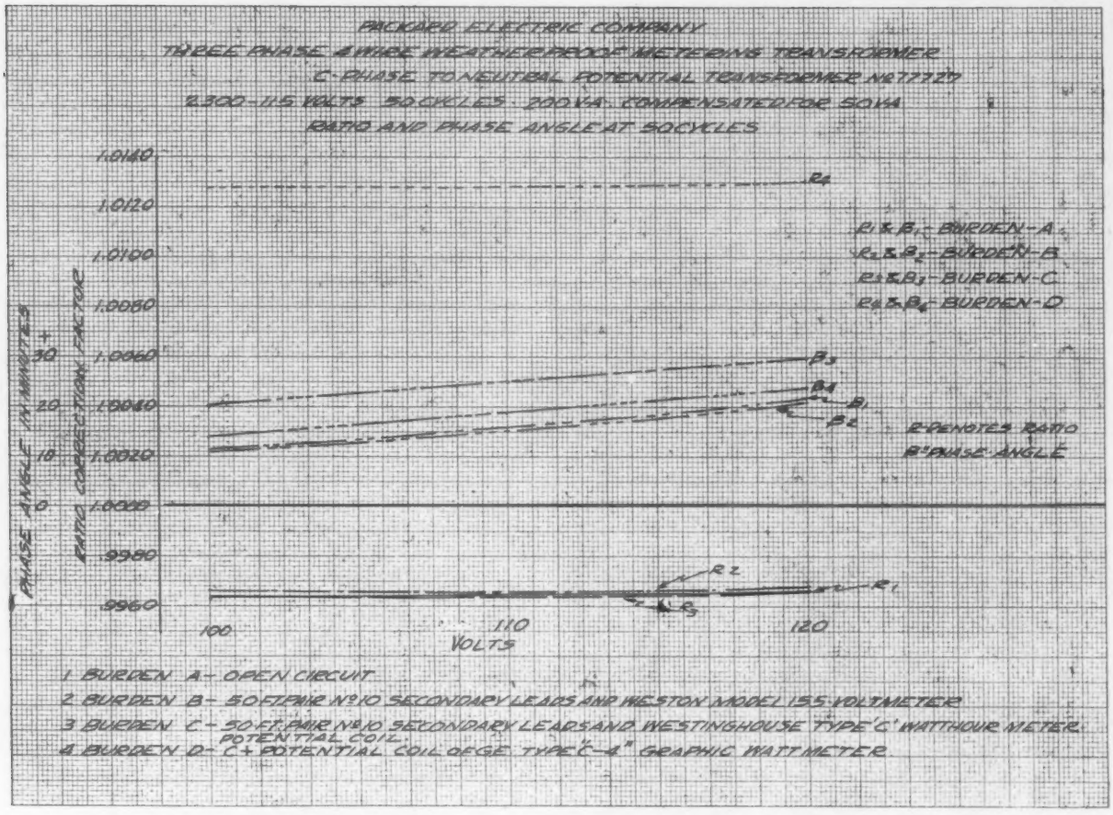


Fig. 9. Test curves on potential transformer.

4 and 5. The oscillograph records indicate the presence of a considerable third harmonic which gives a very distorted wave shape with the neutral floating. Grounding the neutral provides complete correction.

6, 7 and 8. Distortion in wave shape, in itself, had little effect upon the accuracy of the watthour meter.

9. One very interesting feature of this installation is the fact that this distorted wave shape when applied to a synchronous timing motor of the type of the M-10 causes it to run above synchronous speed.

10. The fact that the neutral is not grounded causes a distortion of the star voltage due to the fact that the secondaries are not equally loaded. This condition is entirely corrected by grounding the neutral.

11. The registration error of approximately 17 per cent is due almost entirely to this distortion in the star metering voltages; very little of it is due to the distorted wave shape. This error would vary somewhat depending upon the apparatus connected to the potential transformers. Normally only one meter is connected, in which case the error would be reduced to about 10 per cent.

In all installations where potential transformers are connected in star their primary neutral should be grounded or tied to the neutral of the power bank.

Three-Phase Four-Wire Metering Set

Results of tests on this metering set are shown in Figs. 6 to 9 inclusive. The set consists of three current and two potential transformers, all contained in an oil-cooled weatherproof case equipped with pole-mounting provisions. Construction and arrangement is as shown in Fig. 6. The transformers are held in a shelf-like wooden frame, in grooves cut in these shelves and are anchored firmly in place by wooden strips on either side of the shelves. To replace a transformer unit it is necessary first to remove the primary leads and then lift the wooden structure out of the case, exposing all transformers.

The set was tested first for insulation and found O.K. Phase angle and ratios of current and potential transformers next was determined with a Leeds and Northrup Silsbee test set. Current transformers are double-ratio 50-100/5 amp. 50 colt-amp. and compensated for 15 volt-amp. Potential transformers are 2,300/115 volts, 200 volt-amp. and compensated for 50 volt-amp.

Standardization of Induction Test Meters

The subject of standarization of induction test meters involves many ideas as to methods and specifications of tests. The following contribution is submitted as the standard practice followed by one large utility preparatory to the testing of watthour meters where large power deliveries are involved.

The standardization of induction test meters, commonly referred to as rotating standards, long has been a topic of vital importance to the public utility. This is especially true with respect to the testing of large-delivery watthour meters where the test meter is employed as the standard. The common method of standardization is by comparison with a certified indicating wattmeter over a definite time period. Some companies are not required to consider other than commercial accuracies as limits of error, while in other companies special specifications of tests as agreed upon between the consumer and company limit the tolerances to within a few tenths of one per cent.

The methods described herein have been in use by one company for several years and have been accepted by those interested as complete and accurate within the limits permitted by modern equipment and personal observation. Various modifications of connection and procedure of test have been found necessary, but the fundamental principle has remained unchanged for five years, justifying its acceptance.

In all cases of primary standardizations a Weston model 4 unsaturated standard cell is consideerd as the basic standard. A new standard cell is purchased each year and submitted to the U. S. Bureau of Standards for potential certificaton. In several cases the consumer also furnishes a standard cell for comparison. A Leeds and Northrup potentiometer is employed in the determination of the standard-cell potentials. This potentiometer is submitted to the Bureau of Standards periodically for certification of errors. Cross checks

are made with a Wolff potentiometer and certified resistance standards.

The potential of the standard cell once determined, the errors of a Weston model 326 laboratory standard voltmeter are determined on a d.c. circuit. The corrected mean of the reversed d.c. indication is considered as the comparative alternating voltage value. In the determinaton of the errors of a Weston model 326 laboratory standard wattmeter the certified Weston model 326 laboratory standard voltmeter is employed as a means of maintaing a known potential. Current values are determined with certified shunts and a Leeds and Northrup potentiometer. Again, the corrected mean of the reversed d.c. indication is considered as the comparative alternating current value. The certification of the standard wattmeter embodies every condition required of a transfer standard. That is, considering a transfer standard as a medium of determinig a.c. values in terms of d.c.

Induction test meters to be used as rotating standards are installed permanently in a thermo-

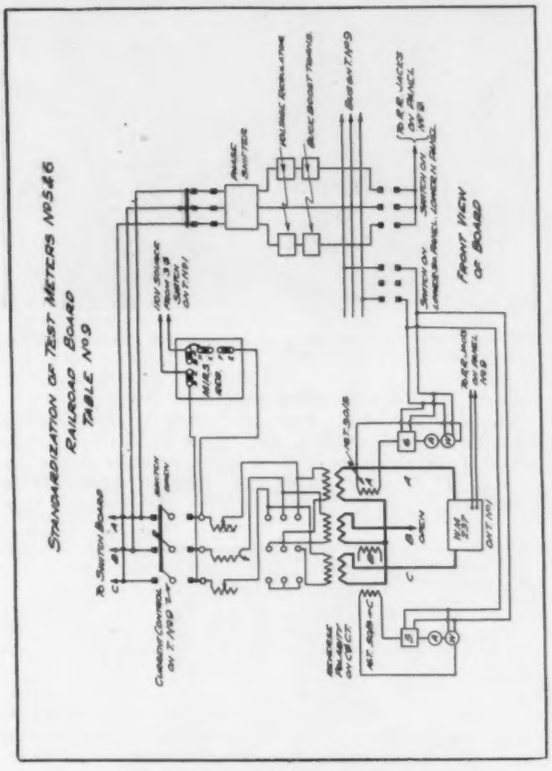


Fig. 10. Standardization of test meters.

statically controlled temperature box in which the temperature is kept constant at 35 deg. C. This procedure eliminates the cause of any possible test-meter registration errors that may result from changes in ambient temperature.

To provide for a wide range of current values Weston model 461 current transformers are used with inserted primary turns enabling the selection of connections for 10, 20, 40, 50, 100, 200, 400 and 800-amp. primary. This is accomplished by the use of selector switches in the primary circuit. Secondary circuits of the current transformers include fixed burdens including in addition to the current coil of the test meter, a Weston model 156 ammeter and the current coil of a Weston model 167 indicating wattmeter for the determination of power factor values when connected in a 3-phase a.c. circuit.

The current transformers with their fixed secondary burdens are investigated periodically by the Silsbee method of comparison with certified standard current transformers to determine the true values of ratio and phase angles. All transformers and instruments are installed permanently in especially designed tables and are never moved or disturbed. Their one duty is solely that of serving as certified laboratory standards. The standardization set-up consists of connecting the apparatus involved by special leads without moving the apparatus. Current transformers are arranged for 50-amp. primary and connected in series with the 50-amp. current coil of the laboratory standard indicating wattmeter.

Current values are obtained from suitable low-voltage loading transformers controlled by the use of adjustable single-phase regulators. A regulated potential source also is adjustable for various angles of lead and lag with respect to the current. Regulation is obtained by the use of an induction-type potential phase shifter.

Five-point curves (20, 40, 60, 80, 100-percent full-load current) are made at 1.0, 0.86, 0.50 and 0.25 power factor, current leading and current lagging.

The current value for the curve point is held constant at the proper wattmeter indications and all the various power factors are investigated consecutively at that point before changing the current to another value. Experience has proved that this permits the use of the two test meters in a subsequent polyphase test at more nearly the same standardization conditions than if a curve is made by changing the current values at a set power factor. The time interval over which a definite amount of power is being considered never is less than 120 sec. and is determined by a second-beating pendulum clock. At low values of current and power factor, twice this interval is taken in order that the inertia error of the test meter may be reduced to a minimum.

Repeated standardizations conducted quarterly over a period of five years reveal that the limits of discrepancy between the results obtained rarely vary more than 0.2 or 0.3 per cent on the unity-power-factor curve; 0.4 to 0.6 per cent on the 0.86 power-factor curve; 0.5 to 0.8 per cent on the 0.50 power-factor curve and from 0.7 to 1.0 per cent on the 0.25 power-factor curve. Considering that the quarterly standardizations are conducted by different sets of observers and under varied seasonal temperature conditions, the results obtained seem to justify the expenditure necessary in the maintenance and operation of this method. This is especially true where large deliveries of power are involved.

Certain testing conditions have necessitated special equipment to expedite the work at hand. In one case the standard test meters are of General Electric manufacture, rebuilt with Sangamo reset dials and adjusted with Westinghouse constants. Fig. 13 shows the method employed in the regulation of the current and potential sources.

Education of Metermen*

During the spring of 1927 three short courses for metermen were sponsored by the P.C.E.A. meter committee.

The first was given under the direct supervision of Prof. R. W. Sorensen at California Institute of Technology, Pasadena, from March 21 to 26, inclusive. The course offered a most complete instruction for anyone connected with electrical metering in all its phases. The second course was held under the direction of Prof. J. C. Clark at the University of Arizona, Tucson, on April 7, 8 and 9. The third course was given at the University of California, Berkeley, from May 16 to 21, inclusive, supervised by Prof. T. C. McFarland. Two courses were offered: Group "A" for those with limited technical experience and group "B" for more advanced men. In general, group "B" pre-supposed a knowledge of the subject matter covered by group "A." This course and the one at California Institute of Technology paralleled each other in the subjects offered as nearly as possible.

Anyone interested in the subject of metering electrical installations, in any organization whatsoever, can profit by attendance at one of these P.C.E.A. meter courses.

* Progress report of sub-committee.—F. A. Redding, chairman. R. Crowell.

New Developments*

Constant-Speed Rotating Standard

A combined rotating standard and loading device weighing only 16 lb. has been developed in the bureau of tests and inspections, Pacific Gas and Electric Com-

* Report of sub-committee.—G. A. Collins, chairman. A. F. Blecksmith, Chris Goldcamp, W. F. Grimes, O. A. Knopp, L. A. Nott, W. C. Smith, H. M. Thomas.

pany. This device makes use of a multi-range current transformer to obtain full-load speed of the standard at all test-current values.

The load and range control is accomplished with one single switch in the center of the standard. (See Fig. 1.)

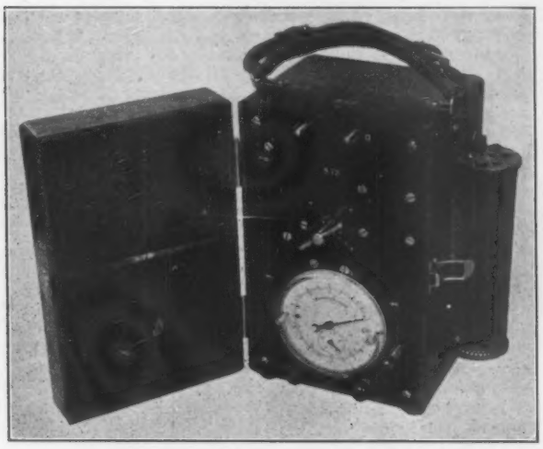


Fig. 1. Knopp constant-speed rotating standard.

The switch provides the following current ranges at each of which the current coil of the standard gets full 5 amp., 0.5, 1, 1.5, 2.5, 5, 10, 15, 25 and 50 amp. Variations between ranges of the multi-range current transformer are said to be of the order of 0.01 per cent in ratio and 1 min. in phase angle.

Advantages claimed for this portable standard are:

1. Light weight.
2. Combined standard and loading device in one unit.
3. Simplicity of control.
4. Simplicity of connections.
5. Operates always at full load.
6. No current-range corrections.
7. No load-curve corrections.
8. Simplicity of calibration, full-load only.

A.C. Meter-Test Bench

This test equipment provides for the testing of single-phase and polyphase meters from 5 to 50 amp. inclusive and at voltages of 110, 220 and 440, at unity power factor, 0.5 power factor, and 10 per cent and 100 per cent load. (See Fig. 2.)

The distinguishing feature of the bench is the use of multi-range current and potential transformers to deliver 5 amp. at 110 volts to the rotating standard at both the 10-per-cent and 100-per-cent load points of the service meter, irrespective of the current or voltage rating of the meter. The application of current-range corrections is unnecessary because the variations in ratio between ranges of the multi-range current transformer are only of the order of 0.01 per cent. The same accuracy holds for the 440-220/110-volt potential transformer.

Aside from the routine testing of service meters this meter test bench provides an ideal arrangement of especially testing equipment for rotating standards, especially if means are adopted to keep potential continuously on the standard test meter to reduce self-heating errors. The equipment was designed and built by the Pacific Gas and Electric Company.

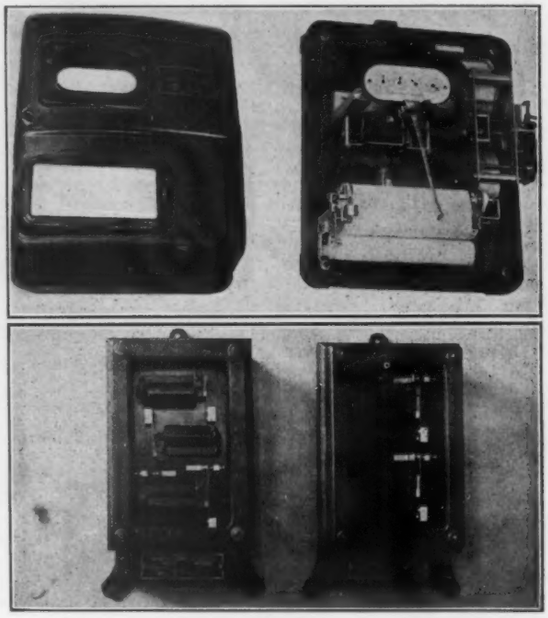


Fig. 3. Knopp demand recorder (above) and Knopp multiplex contactor (below).

Demand Recorder

The demand recorder shown in Fig. 3 registers the total kw-hr. and gives a strip-chart record of the demand of the combined load of several meters either a.c. or d.c. It is made up of the essential parts of the Westinghouse RA. demand meter, the solenoid and ratchet device of the General Electric M-4 register and the Knopp-Multiplex-Contactor. The recorder is operated from contacts installed in the watthour meters.

TABLE I—Possible errors due to mutual inductance with normal potential applied.

Type Wattmeter	Range Amps.	Volts	Watts	Possible Error Watts	Per Cent Full Scale
G. E. P-4	5	150	500	4.0	0.8
Weston Model 310	5	150	750	1.5	0.2
Weston Model 310, Form 2	0.1	150	3.0	0.054	1.8

Combination Torsion-Head and Indicating Wattmeter

The ordinary dynamometer-type of wattmeter has several inherent errors which must be taken into ac-

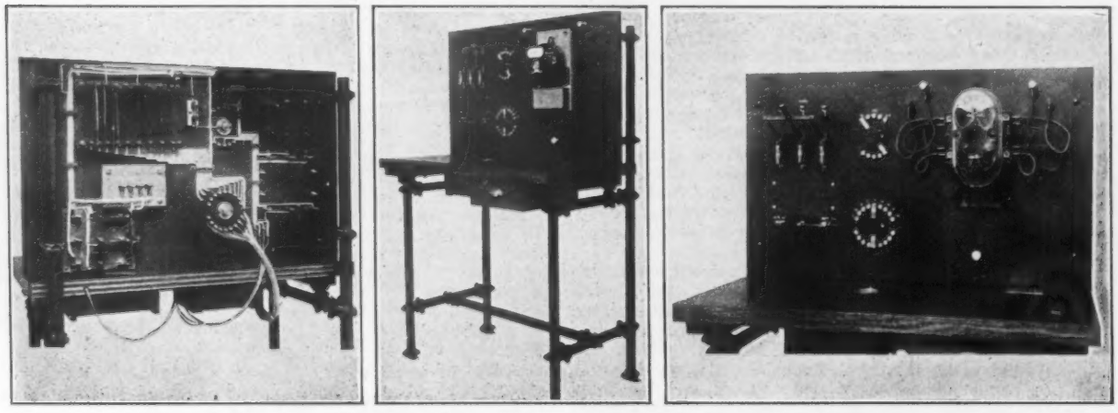


Fig. 2. Knopp a.c. meter-test bench

count when making accurate measurements. Among these is that caused by the mutual inductance between the moving or potential coil and the stationary or current coil of the wattmeter. When current is allowed to flow in the potential coil it sets up a slight potential in the current coil, due to this mutual inductance, which causes a current to flow according to the impedance of

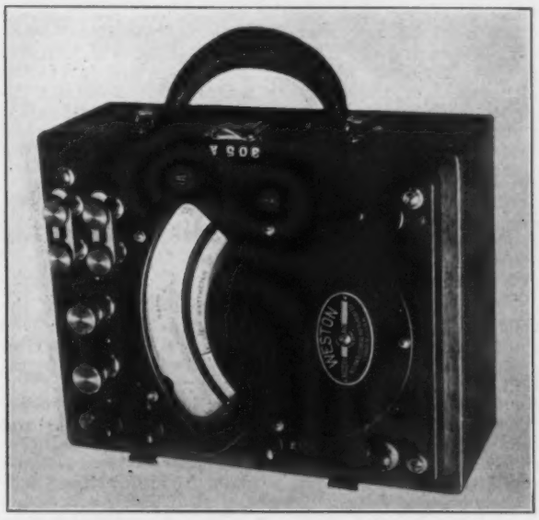


Fig. 4. Combination torsion-head and indicating wattmeter.

the whole current circuit and which adds to or subtracts from the load current that is being measured, causing an error in the reading. Where the impedance of the external circuit is high this error is negligible, but where the current coil is connected to a shunt or current-transformer secondary or other low-impedance circuit it may cause an appreciable error. The greatest error due to this cause occurs when the pointer is at zero and again at maximum position on the scale.

The mutual inductance between these two coils is at its maximum when the coils are parallel and is zero when they are at right-angles. This right-angle position occurs, in most modern wattmeters, at the middle position on the scale. The error thus can be eliminated by keeping the moving coil always in the position of zero mutual inductance. As an illustration of the possible errors that may exist in various types of wattmeters, Table I is submitted.

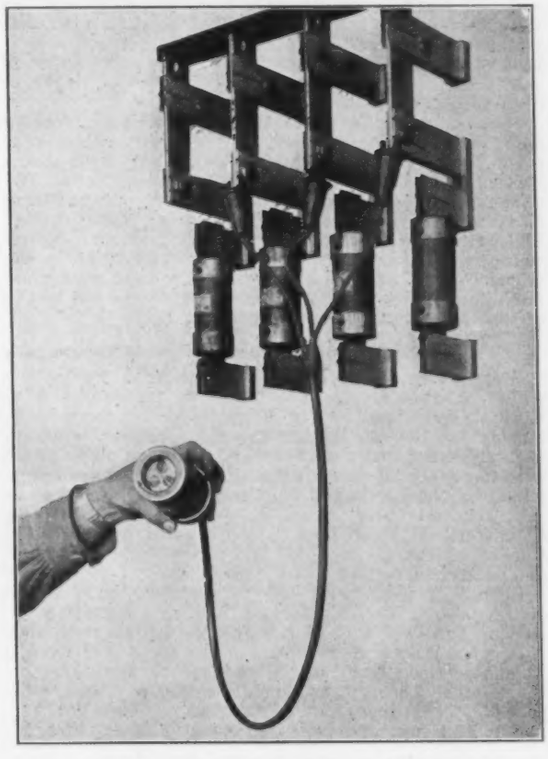


Fig. 5. Knopp phase-sequence indicator.

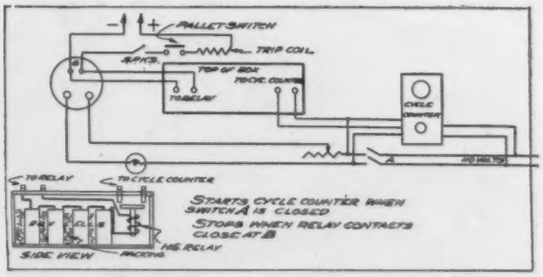


Fig. 6. Auxiliary equipment for testing relays.

Where small deflections of from 3 to 8 divisions are being read the per cent error may be as much as from 10 to 20 times the per cent values shown in Table I.

Recognizing that this error may be grave in certain measurements the Pacific Gas and Electric Company's laboratory has developed a torsion-head which, when applied to wattmeters of the dynamometer type, entirely eliminates this error. (See Fig. 4.)

It consists of a revolvable pointer and thumbnut fastened in the top of the bakelite cover of the meter, the axis of rotation of the meter is in line with the axis of the moving coil. To this device is fastened the end of the movement spring which ordinarily would be fastened to the frame of the instrument. The indicating pointer holds a zero position in the center of the scale in which the moving coil is in the position of zero mutual inductance. When current is applied the indicating pointer tends to deflect one way or another and the operator revolves the torsion pointer which, by placing a torque on the spring, causes the indicating pointer to return to zero. Thus the reading of the watts is obtained by reading the deflection of the torsion pointer over a specially calibrated scale.

Phase Sequence Indicator

Fig. 5 illustrates a rugged, light-weight, phase-sequence indicator designed to operate on one voltage range of 30 to 500 volts. This was developed by the Pacific Gas and Electric Company.

Relay Test Apparatus

The test department of the Southern California Edison Company has developed a method of making secondary tests on relays without removing any leads from the relay contact terminals. (See Fig. 6.) The relay operates the cycle-counter through a portable 12-volt HG relay and 4 dry cells. A single-pole knife switch installed near the relay in the positive lead to the trip coil is used to disconnect the relay from the station battery during the test.

Meter Transportation*

In dealing with the subject of meter transportation it is necessary to divide it into two classes: First, methods used by the meter department where specially built cars can be had exclusively for this work and for metemen only; second, facilities for transporting meters by service men or line crews where the trucks are used for purposes other than carrying meters. The method used depends upon the size of the company, and the number of meters handled.

If a power company is fortunate in being large enough to have special cars for its meter department, this unquestionably is ideal. If, on the other hand, the company must use the cars for other purposes such as complaints, servicing ranges, etc., facilities must be provided to take care of meter work as well. From experience and observation the other work has been considered in the past as being the more important with

* Report of sub-committee.—J. C. Abel, chairman.

the result that meters are carried about in most any way to get them to the job. No consideration is given for their care at all, whether the jewels are cracked, the cases dented and scratched or the glasses broken.

There is some difference of opinion as to the proper position of the meters when being carried. Some think

Fig. 1. Meter transportation on truck of San Joaquin Light & Power Corporation.

they should be transported in an upright position to reduce a tendency of a possible shift of the permanent magnets, should they not be securely tightened. Others prefer to have them lying flat in order to relieve the strain on the jewel bearings. This last method appeals

Fig. 2. Meter car of Pacific Gas and Electric Company.

to most companies and perhaps is an easier arrangement, although some member companies use the first method.

It would seem that the position of meters is not nearly as important as the cushions upon which they rest in transportation. With any make of car the springs serve to reduce vibration provided the load is properly distributed. Use of specially built bodies with separate compartments, carefully padded with heavy felt

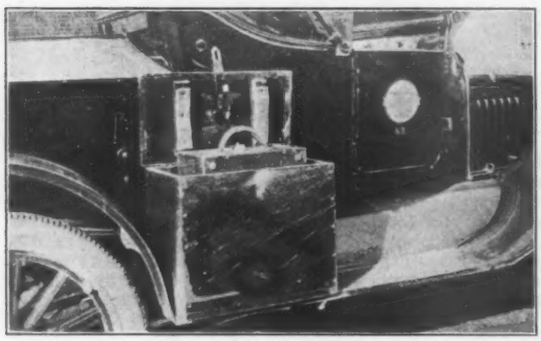


Fig. 3. Special compartment for rotating standard, Western States Gas & Electric Company.

or lined with soft carpet under which cotton batting has been placed, will reduce breakage to a minimum and should insure proper care to the meters under all conditions met with in ordinary practice. Some member companies use the original containers in transporting meters with very satisfactory results. Direct-current meters having brushes are more delicate and require more care than induction meters. Therefore heavier padding is necessary for their protection.

In arriving at a definite conclusion as to just what method would be the best, it could be said that any facilities for protecting meters from undue vibration, from becoming scratched or dented, and from having other material such as coils of wire, insulators, crossarm braces and the like piled upon them, are sufficient protection. Undoubtedly all meter men will agree that if the size of the company warrants it, specially designed bodies on meter trucks offer the best and safest method of meter transportation. Further, the original containers are satisfactory where the company is not large enough to have special equipment.

The Testing of High-Voltage Metering Equipment*

Proper performance, maintenance and testing of the watthour meter and its appurtenances long have been considered by the electric utility as one of its most vital and important functions. From the initial consideration by the electrical manufacturing company to the final installation on the consumer's premises, no other class of apparatus is subject to such rigid tests and critical inspection with respect to accuracy and precision as is the watthour meter. It is true that no small amount of concern is given to high-voltage machines, lines and transformers, each in itself representing a large investment of capital which justifies a close inspection to insure continuity of operation and safety to life and property. However, late developments in apparatus used in transmitting power at extremely high voltages impose an additional duty upon the watthour metering equipment, if the power is to be metered accurately.

Contrasting the initial costs of high-voltage generating and transmitting equipment with the metering apparatus the latter is found to represent but a small part of the total investment. Nevertheless, its duties are equally important if a full return on the total investment is to be obtained. Methods employed by different power companies in the maintenance of metering apparatus are of wide and varied nature. Some companies give more attention to certain phases of the work than others and it is with that point in mind that this paper is submitted in an effort to give, in a general way, the procedure as followed by one California utility in the metering of large deliveries of power at high voltages.

Preparatory to the installation of metering apparatus on a contemplated delivery line, due consideration is given to the conditions involved and instrument transformers are selected according to these conditions. The apparatus is sent to the test department standardizing laboratory for certification of accuracies. Specifications for certification include every detail that may be encountered in service which can be duplicated in the laboratory. This includes operating voltage, maximum and minimum load, average power factor and the length of instrument-transformer secondary leads.

Preparation of Instrument Transformers

Preparatory to the initial installation in service the potential transformers are tested in accordance with A.I.E.E. specifications for dielectric values from high-tension winding to the grounded low-tension winding. If found satisfactory the errors of ratio and phase angle with the expected operating secondary burden are determined by the Leeds and Northrup method of comparison with laboratory-standard potential transformers, the errors of which have been certified by the U. S. Bureau of Standards. Ratio and phase-angle errors are determined in service every five years.

Current transformers also are given the A.I.E.E. dielectric test. The transformer then is demagnetized by passing full-load current through the primary winding with a resistance of 20 ohms. in the secondary circuit. This resistance gradually is reduced to zero, keeping the secondary current as nearly constant at 5 amp. as is possible. This procedure permits an accurate determination of the discrepancies between "as left" and "as

*Report of sub-committee on special tests and investigations.—L. L. Conrad, chairman. W. N. Lindblad.

found" tests due to the current transformers over the period of service. Errors of ratio and phase angle then are determined by the Silsbee method of comparison with laboratory-standard current transformers, the errors of which have been certified previously by the U. S. Bureau of Standards.

Preparation of the Watthour Meter

The watthour meter is completely dissembled and the interior is painted white to assist in locating possible foreign matter during subsequent tests and inspections. In the re-assembly of the meter each part is inspected closely for imperfection of material or workmanship. This includes the counting of the teeth in the gear train. The combinations of gears are etched on the metal frame of the gear train assembly to enable a rapid re-check of the gear ratio.

In some few cases it has been found desirable to install with the watthour meter an indicating wattmeter for the convenience of the consumer in regulating loads.

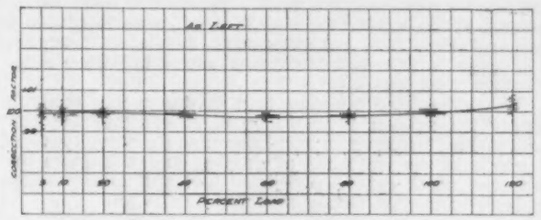


Fig. 1. Composite "as left" characteristic curve of 38 different watthour meters, representing two semi-annual meter changes.

In this event the indicating wattmeter also is thoroughly inspected and is scaled to the full-load value of the instrument transformers involved.

Watthour Meter Testing Equipment

To facilitate the adjustment and testing of the watthour meter a special testing table has been provided and equipped with all the appurtenances necessary to duplicate conditions under which the watthour meter will operate when in service. This equipment includes potential regulating devices and certified voltmeters. A phase shifter is used in leading or lagging the potential cricuit with respect to the current circuit to permit a flexible means of duplicating service power-factor conditions.

Load adjustment is accomplished by the use of current regulators connected in the 110-volt star-delta primary of a bank of low-secondary-voltage transformers. In this low-voltage circuit the watthour meter current transformers are connected, also the standardized current transformers for the rotating test meters. The ratio-changing device for the standardized rotating test meter current transformers consists of a combination of double-pole double-throw switches permitting instant selection of ratios of 800, 400, 200, 100, 50, 40, 20 and 10 primary amp. to 5 secondary amp.

In addition to the rotating test meters the secondary circuit of the standardized current transformers includes certified indicating ammeters, wattmeters and a power-factor meter used to determine accurately the load and power-factor conditions. Certified single-phase rotating test meters are kept in a heat-lagged, thermostatically controlled temperature box. The internal temperature is kept constant at 35 deg. C. within the limits of one degree plus or minus. This procedure has been found to be necessary in eliminating temperature errors, inherent in the meters, due to seasonal changes in room temperatures.

Watthour-Meter Connections

Test specifications require that consideration be given to the line operating conditions with respect to the high and low registering elements. Current transformers are marked plainly, indicating to which meter element and line conductor they are to be connected. This combination never is broken up except in circumstances that require new current transformers or a new watthour meter. The individual elements of the watthour meter are connected to the designated current transformers through resistances which are equivalent to the secondary leads involved.

After all connections are made, duplicating service conditions with the exception of the potential transformers, the circuit is energized at 80 per cent of full load at system voltage and power factor. The watthour meter then is operated for approximately one hour to compensate for any differences between room temperature and the normal operating temperature within the meter case. Full-load adjustment is made at this point and left at an error of less than 0.5 per cent fast. The light-load adjustment point (20 per cent of full load) is investigated next and left with the same degree of accuracy.

Accuracies of the two elements run separately at 80 per cent load, unity power factor, single-phase, and are varied by modifying the conditions of the magnetic circuit until the discrepancy of registration is less than 1 per cent. During the investigation of each element the potential circuit of the other element is kept energized. Power-factor compensation is made at 80 per cent load and 0.50 power factor. One element is adjusted to have a discrepancy of less than 0.5 per cent at 0.50 power factor with current lagging with respect

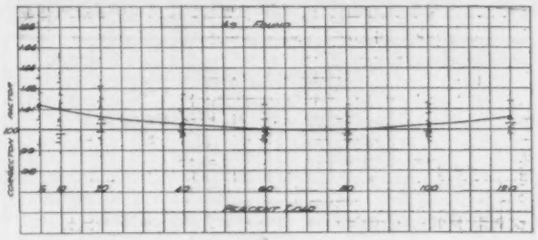


Fig. 2. Composite "as found" curves of 38 different watthour meters, representing two semi-annual meter changes.

to the registration at unity power factor. The other element is given the same limits of tolerance between unity power factor and 0.50 power factor, current leading, with other conditions remaining the same.

After the various adjustments are made re-checks are taken to determine the effects of the adjustments, if any, needed on the light-load and 80 per cent load registration. Additional adjustments are made if found necessary. This, however, rarely is the case because in general the power-factor modifications are of a small amount and do not affect greatly the previous "as left" conditions.

At this point investigations are made to determine the accuracy of the meter on a 3-phase circuit at 80 per cent load and 0.50 power factor, current leading, and current lagging. This condition imposes a normally

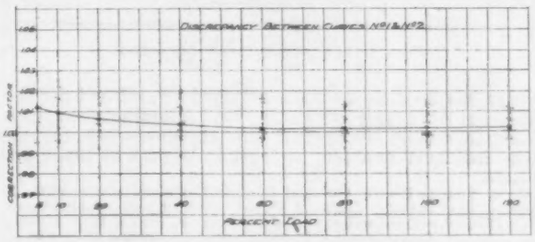


Fig. 3. Curves showing discrepancy between curves of Fig. 1 and curves of Fig. 2.

low lagging and an abnormally low leading power factor on the meter, for in each case one element is operating at a power factor of 86 per cent and the other element at zero power factor. If the registration is found to be within the limits of 1 per cent plus or minus, as compared to the registration at normal operating power factor, the meter is considered suitable for an operating-characteristic-curve test.

Under duplicate conditions of voltage and power factor a 7-point correction-factor curve is made from the inaccuracies found from 10 to 110 per cent full load, including the errors due to the potential transformers. The correction factor curve is used by the billing department in calculating the consumer's bill over a period of five months following the installation of the metering equipment.

Semi-annually a complete new metering equipment (less the potential transformers) is prepared for exchange. Under the supervision of a representative of

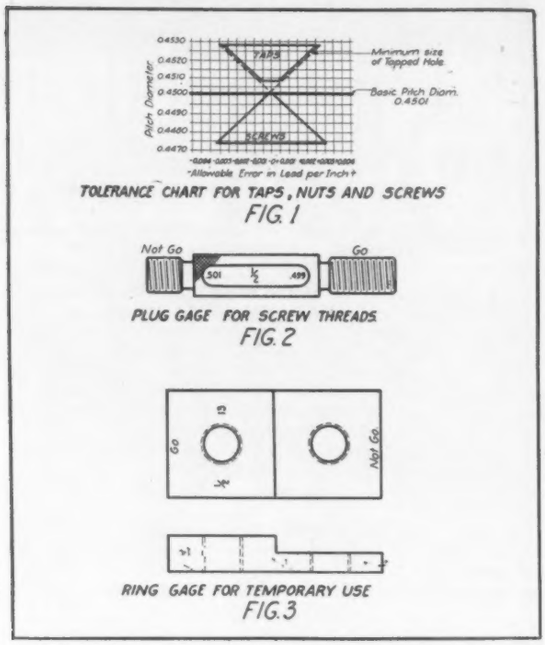
the power company and a representative of the consumer the equipment is exchanged. The apparatus removed is returned to the standardizing laboratory where an "as found" investigation is conducted. The results of the "as found" test are used by the billing department in calculating the delivery over a period of one month priof to exchange of metering equipment.

Accompanying curves show the composite characteristics of 38 different meters through two semi-annual periods representing the metered delivery of more than 305,000,000 kw-hr. The curves show conclusively that in the aggregate the variable conditions of light-load registration will justify precision test methods and frequent exchange periods.

Overhead Systems Committee Reports[1]

Standardization of Pin and Insulator Threads and Thread Gages*

Since the adoption of standards for 1-in. pin and insulator threads by the N.E.L.A. in 1922 and 1923 certain difficulties have arisen in connection with 1⅝-in. pins and insulators, particularly on the larger sizes used on transmission circuits of the higher voltages.



Figs. 1, 2, 3. Screw thread tolerances.

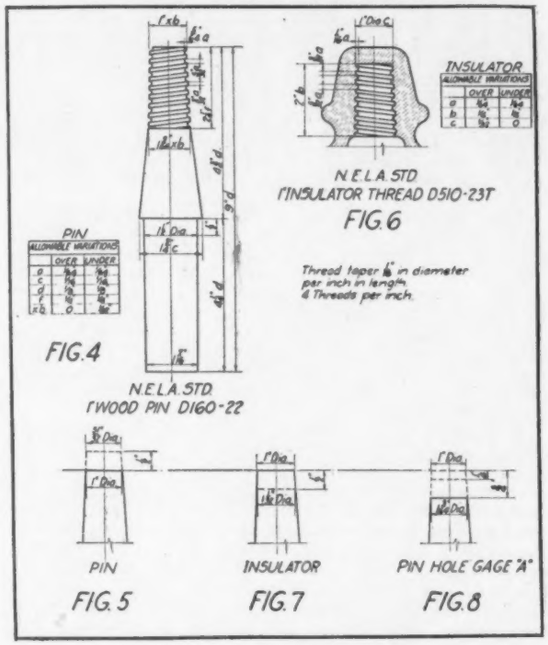
There has been no definite standard established for this size, but operating companies and manufacturers have been following in general the standards set for the 1-in. insulator and pin, at least in regard to taper and pitch. The matter was brought up from time to time in the P.C.E.A. overhead systems committee, but no definite action was taken until January, 1926, when a certain 1-in. insulator gage was proposed for adoption. This is later referred to as Gage "A." A subcommittee then was appointed to pass upon the proposed gage and to make such further studies as seemed desirable.

This gage was modified and was sent to a number of member companies for trial. While the tests as reported at the Fresno meeting in April were favorable in general, they were not exhaustive. Insulators accepting the gage within the tolerances suggested were satisfactory, that was all.

The committee believed that it was worth while to study the subject more fully; to investigate the considerations involved in insulator manufacture, types of threads in use, methods of gaging, and maximum tolerances which can be permitted and still allow the insulator to remain firmly mounted on the pin.

History

The first suggestion that insulators and pins be threaded was presented in 1865, shortly after which the idea was adopted by the Western Union Telegraph Company.[1] The inventor whittled out a model which was used as a pattern. Two bronze pins were cast from it and used as standards. These had four threads per in.



Figs. 4, 5, 6, 7, 8. N.E.L.A. standards, and gage "A."

and a taper of 1.111 in. in diameter per ft. of length. It is believed that the pitch was intended to be 3/32 in. per ft., or 1.125 in. per ft., the difference between 1.125 and 1.111 having come about by shrinkage or error. This still is the standard taper for all Western Union and Bell System insulator and pin threads.

Ordinary Screw Threads

It is well to note what methods of gaging are used in the older field of straight screw threads. These are summarized quite fully in a report of a committee of

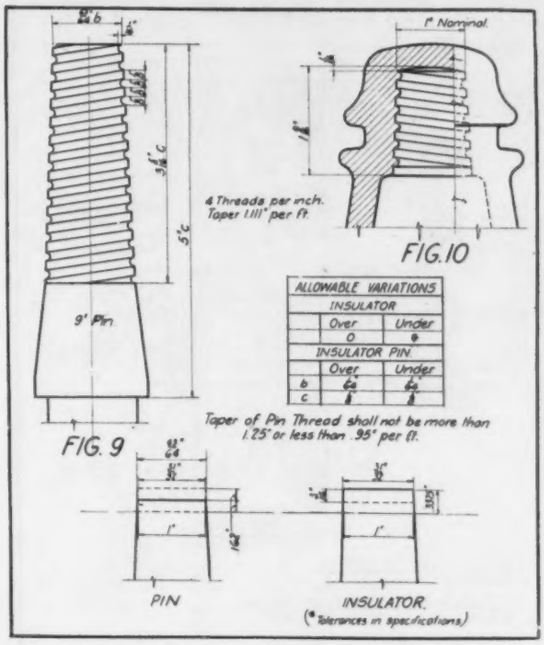
[1] **C. E. Young,** Pacific Gas and Electric Company, chairman. **H. H. Minor,** San Joaquin Light & Power Corporation, vice-chairman. **The California Oregon Power Company:** S. M. Bullis, R. S. Daniels, O. G. Steele. **Coast Counties Gas & Electric Company:** A. E. Strong, W. R. Van Bokkelen. **Coast Valleys Gas & Electric Company:** T. W. Snell. **Farnham & Cunningham:** R. E. Cunningham. **Graybar Electric Company:** J. E. Crilly. **General Electric Company:** D. Anzini. **Great Western Power Company:** C. F. Benham, M. N. Clark, G. H. Hagar. **Hubbard & Company:** R. M. Kerschner. **Kortick Manufacturing Company:** J. C. Kortick. **Los Angeles Bureau of Power & Light:** G. A. MacDonald. **Los Angeles Gas & Electric Corporation:** F. E. Dellinger, G. A. Riley. **Los Angeles Joint-Pole Committee:** J. E. Macdonald, **Maydwell & Hartzell:** H. F. Hartzell. **Midland Counties Public Service Corporation:** D. D. Smalley. **Ontario Power Company:** C. W. Walker. **Pacific Coast Steel Company:** H. G. Sharp. **Pacific Gas and Electric Company:** W. B. Allett, H. H. Buell, N. P. Carlsen, Jr., L. J. Corbett, R. R. Cowles, O. R. Evans, P. J. Freygang, F. R. George, H. S. Lane, C. E. Larrabee, J Mini, Jr., R. W. Muller, R. C. Seagren, W. D. Skinner, A. J. Theis, J. O. Tobey, R. W. Wilkins. **The Pacific Telephone & Telegraph Company:** D. I. Cone. **San Diego Consolidated Gas & Electric Company:** K. B. Ayres, A. S. Glasgow, C. C. May. **San Francisco Joint-Pole Committee:** E. C. Fisher. **San Joaquin Light & Power Corporation:** E. R. Banks. **Southern California Edison Company:** C. F. Andrews, R. G. Boyles, W. P. Champion, R. B. Guilbault, C. E. Heath, J. F. Hodges, H. Mitchener, E. R. Stauffacher. **The Southern Sierras Power Company:** P. W. Greenleaf, H. H. Miller, E. Y. Porter, A. C. Putnam. **Truckee River Power Company:** V. D. Armstrong. **Western States Gas & Electric Company:** E. N. D'Oyly, E. S. Moreland. **Westinghouse Electric & Manufacturing Company:** S. L. Case, W. L. Winter. **Miscellaneous:** B. C. Holst.

* **Report of sub-committee.—L. J. Corbett, chairman.** K. B. Ayres, F. E. Dellinger, R. B. Guilbault, G. H. Hagar, G. A. MacDonald, C. C. May, H. H. Minor, E. Y. Porter, G. A. Riley.

[1] Preliminary Report A.E.R.A. power distrib. com., 1916.

the A.S.M.E. published in the society's transactions for 1920.

A typical tolerance diagram for bolt and nut is shown in Fig. 1. The screw, it may be noted, must not have more than the basic pitch diameter. The tap or nut has a minimum somewhat greater than the pitch diam-



Figs. 9, 10. Bell System 9-in. pin and toll-line insulator.

eter and the tolerances all are above this figure. Apparently the N.E.L.A. followed this requirement in standardizing its 1-in. insulator and pin threads.

In addition to fine micrometer gages for checking thread shape, pitch, etc., working gages of the plug and the ring type are used for taps and screws respectively. The plug gage of Fig. 2 has one end small and the other large, the ends being marked "GO" and "NOT GO" respectively. The "GO" plug is as long as the longest requirement. The "NOT GO" plug is short, for the extra length is not necessary. The ring gage

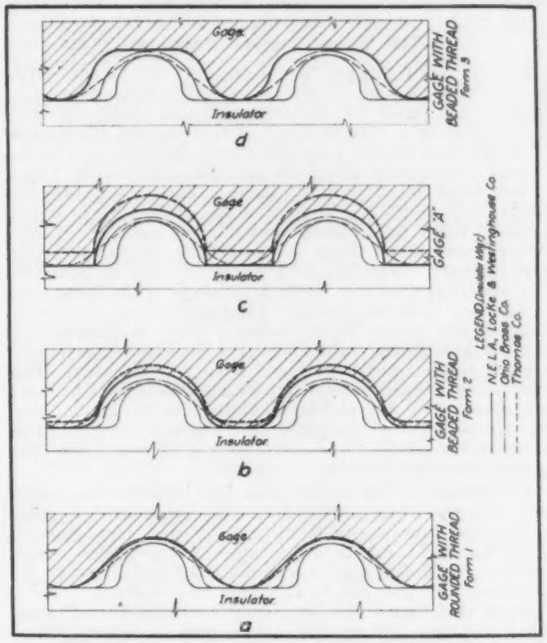


Fig. 11. Commercial insulator threads compared with various thread gages.

of Fig. 3 likewise is threaded large at one end and small at the other. The "GO" ring is as long as the longest requirement and the "NOT GO" ring is short.

N.E.L.A Insulator and Pin Threads

The methods of the mechanical engineers evidently were followed by the N.E.L.A. committee, the tolerances for insulator and pin threads being in the same relation as those for nuts and screws. The N.E.L.A. standard 1-in. pin thread is shown in Fig. 4, the standard insulator thread in Fig. 6. Tolerance for the pin is given as from 0 to 1/32 in. under nominal diameter and the tolerance for the insulator as from 0 to 1/32 in. over. Thus it is possible to pass an insulator 1/32 in. oversize and a pin 1/32 in. undersize. The combination will tend to force the top off the insulator. The shapes of the theoretical cobs and the tolerance limits interpreted in length from the top of the exact cob are shown directly below these drawings as Fig. 5 and Fig. 7.

The pin thread is a gouged thread on a straight cone frustum. There are four threads per in. and the taper is 1/16 in. in diameter per in. of length. The groove is of semi-circular section 5/32 in. in diameter. The flat ridge between is 3/32 in. across.

The insulator thread is exactly the reverse of the pin thread, the ridge or bead being a semi-circular section 5/32 in. in diameter and the flat valley 3/32 in. across. This evidently is based upon the wood thread. The metal pin thread either is not considered in its full range of possibilities or it was thought to be as simple a matter to imitate the wood thread in metal, and the reverse in porcelain.

Telephone and Telegraph Insulator and Pin Threads

The telephone and telegraph companies use the 1-in. threads shown in Fig. 9 and 10 for pin and insulator respectively. There are four threads per in., but the taper is 1.111 in. in diameter per ft. of length. The cobs shown below these drawings indicate the tolerances. For insulators the tolerances are set by the gaging specifications, analysis of which shows the limits to be from about 1/64 in. to 1/32 in. smaller in diameter than the standard shown.

In pins the tolerance is 1/64 in. undersize to 1/64 in.

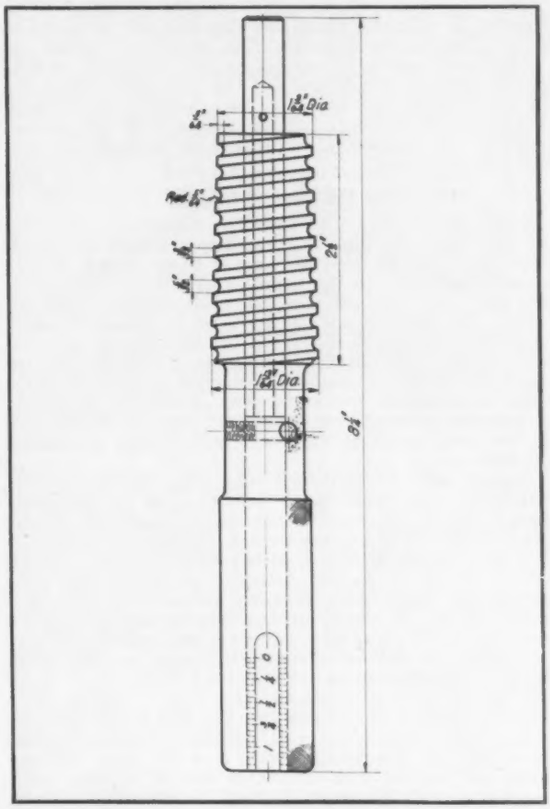


Fig. 12. Gage "A" as proposed January, 1926.

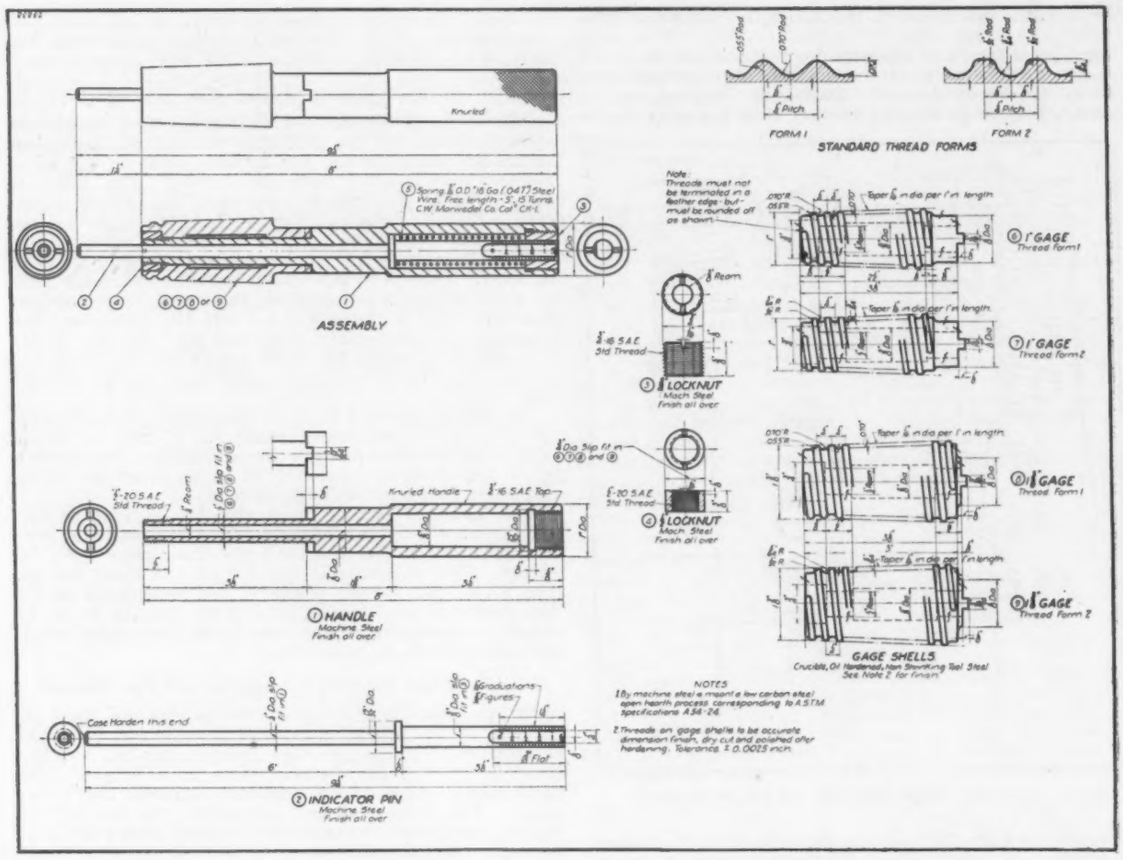


Fig. 13. Gage with removable shells, for 1-in. and 1⅝-in. insulator pin holes.

oversize in diameter from the standard pin, or from 1 in. to 31/32 in. in diameter. The ridge and valley on the pin each are ⅛ in. across, as also are those on the insulator. Glass insulators for the telegraph and telephone interests are made to the Western Union and Bell System's standards; those for the light and power industry are made to correspond in general to the N.E.L.A. standard.

The Problem of Gaging

Some of the shapes of insulator threads in common use are shown in Fig. 11. Selecting a proper shape of gage thread to be used for any of these shapes is the present problem. In the manufacture of insulators the pin hole will vary in top diameter, in pitch and in taper. The limits in each case should be set as liberally as will allow a reasonable fit of the insulator on the pin in all cases. The pin should measure closely to a given standard. It also is subject to variation, but less than glass or porcelain insulators. Any acceptable insulator of a given nominal size should fit any acceptable pin of the same nominal size in a substantial, workable manner.

A gage with a flat thread (like gage A, Fig. 11, C) will serve very well for a beaded type of insulator thread, but if too close to the insulator thread in dimensions it will not permit much variation in pitch. If it is used on an insulator with rounded thread, it will not go in as far as will a wooden or soft-metal pin. However, a gage with rounded thread (Fig. 11, A) would serve very well for the beaded thread insulators, but unless the ridges are made much sharper than the valleys it will not give much leeway on the pitch when used with rounded thread insulators.

A beaded type of gage thread (Fig. 11, B) is proposed for study, one which has the flat outer surface of the Type A gage, but with rounded corners. A gage is subject to appreciable wear and the flat surface would last longer than the ridge line of a gage with rounded thread. However, it may be advisable to use a thread like Form 3 (Fig. 11, D) to permit suitable latitude in diameter, taper and pitch to suit any type of insulator thread.

The shape of thread for the gage to be finally adopted should be such that it will enter insulators with threads of any of the commercial shapes as it is not the object of the committee to bring about sweeping changes in any manufacturer's product.

The Manufacturers' Problem

In the manufacture of porcelain insulators, with which the present study is chiefly concerned, the threads are made by screwing a metal bland into the plastic clay at a certain stage of the process. Shrinkage to be allowed varies with the shape and size of the insulator, averaging about 15 per cent. When the bland is new some quality of the surface causes varying adhesions and there is a large wastage of insulators which already have had considerable labor put into them. After some wear there is very little wastage, hence manufacturers like to use a bland as long as possible. The result is that the bland is made a trifle large and is used as long as possible. Insulators from the early batches are large in diameter. Then a number of batches are about right and later batches successively become smaller until the bland finally is discarded. The adoption of tolerances that are too rigid will tend to limit the number of acceptable insulators to be made from one threading tool, increase the wastage of insulators in the early batches and consequently increase the cost of insulators to member companies.

The situation regarding pins also affects the problem. As the taper on the 1-in. pins made for the communication companies is almost 50 per cent greater than the N.E.L.A. standard taper, wooden pins which are too small for use on communication lines may be re-shaped to the N.E.L.A. taper and thread. It is claimed that many pins thus are re-machined and marketed and that this results in 1-in. pins in general being too small. Natural shrinkage has the same tendency. To meet this situation insulators have been allowed to

be smaller than standard in order better to fit the general average wooden pins.

Types of Gages

The shape of thread in the gage to be adopted is the paramount consideration. This feature has not been definitely agreed upon by the committee. The mechanics of the gage form a secondary feature in which there is much choice available and where the ingenuity of designers may have considerable play. A number of gages are shown in accompanying illustrations together with their different threads and mechanisms for determining tolerances.

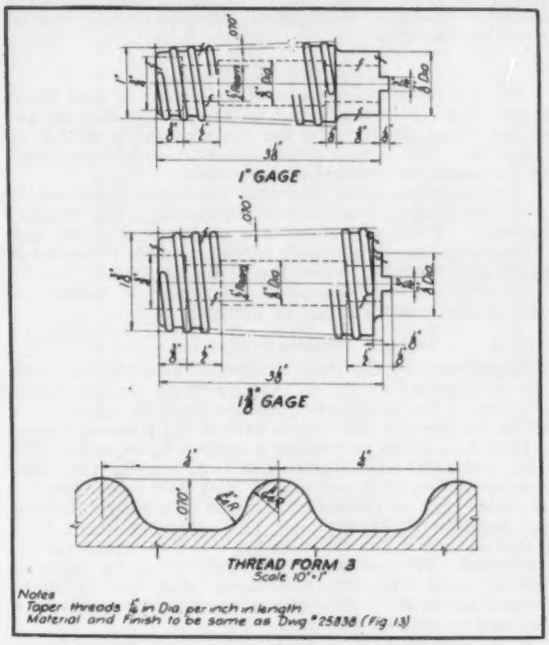

1" GAGE
1 3/32" GAGE
THREAD FORM 3
Scale 10"=1"
Notes
Taper threads 1/16 in Dia per inch in length
Material and Finish to be same as Dwg #25838 (Fig 13)

Fig. 14. Gage shells, and development of thread form 3.

Gage A offered in January, 1926, is shown in Fig. 12. This has the N.E.L.A. standard pin thread and taper, but is 1 3/32 in. in diameter at the end. This is equivalent to cutting ¾ in. off the end of the standard cob, as shown in Fig. 8. The tolerances specified for this gage were that it should enter the insulator to a position not less than ¼ in. nor more than ¾ in. from the end. This corresponds exactly with the N.E.L.A. allowances of 1/32 in. in diameter oversize and undersize. This gage is used by the distribution department of the Pacific Gas and Electric Company for gaging 1-in. insulators. The gage used by one insulator manufacturer is similar in shape of thread, but is made on a full theoretical cob.

The hydroelectric and transmission division of the Pacific Gas and Electric Company brought out a gage similar to Fig. 13 with Form 1 thread (rounded) that is used for 1⅜-in. insulators. The cob is full theoretical size. The present tolerances are shown in Fig. 15.

Another insulator manufacturer uses a gage with the same type of thread, but on a cob 1/32 in. undersize at the end. In other words the cob extends ½ in. beyond the end of the theoretical cob. This gage must enter to within ⅜ in. from the bottom in the factory inspection. The hole in the insulator then may be still more than 1/32 in. undersize in diameter even with part of this allowed for the arch.

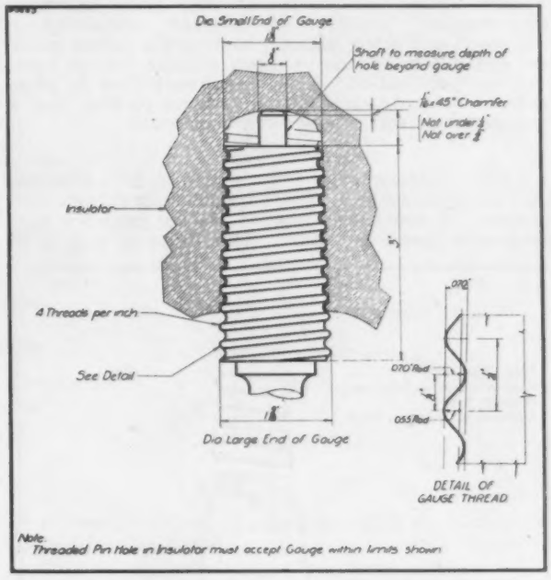

Dia Small End of Gauge
Shaft to measure depth of hole beyond gauge
1/16 x 45° Chamfer
Not under 1/8"
Not over 1/4"
Insulator
4 Threads per inch
See Detail
Dia Large End of Gauge
DETAIL OF GAUGE THREAD
Note
Threaded Pin hole in Insulator must accept Gauge within limits shown

Fig. 15. Tolerance limits for 1⅜-in. insulator pin hole.

The gage shown as Fig. 16 was proposed by the Southern Sierras Power Company. In applying this gage (See Fig 16) the outer sleeve, which is the gage for base of pin hole, would be slipped back against the shoulder at knurled end of the inner or tip gage. The latter then would be screwed into the insulator and depth indicated by the graduated plunger. Leaving the tip gage in position, the outer sleeve or base gage then would be screwed into the insulator to a snug fit. Irrespective of the position of the tip gage, if the insulator has a standard taper the base gage should indicate the gage 0 position on the graduated barrel of the tip gage. If the taper is greater than standard the gage will go in deeper, and vice versa. The variation is indicated by the scale on the barrel of the gage. While there is no doubt as to the effectiveness of this gage, there is doubt as to the necessity for such an accurate gage.

The type of gage used by the Western Union and Bell System is shown in Fig. 17. This gage has a full rounded thread and is made from a full theoretical cob with the requisite taper for their insulators. Specifications for gaging include the tolerances permitted.

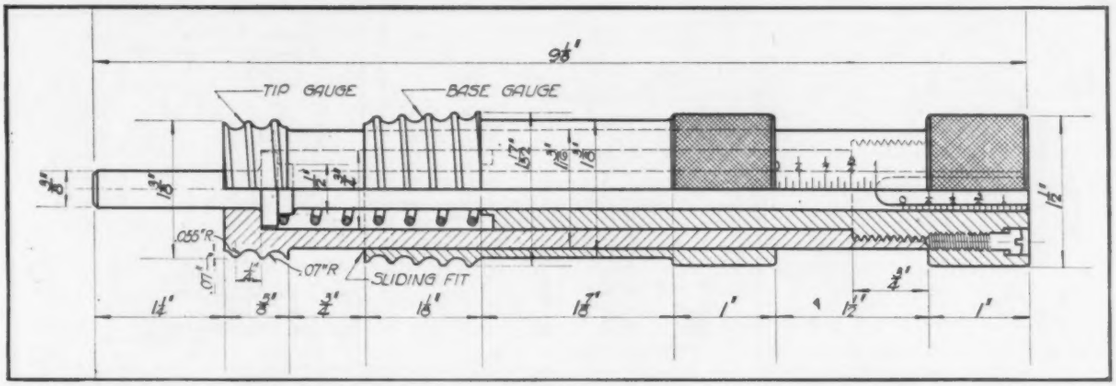


Fig. 16. Insulator gage for 1⅜-in. pin hole, proposed by The Southern Sierras Power Company, threads to be formed of standard shape and at standard taper when tip gage and base gage are in the relative position shown. See text for explanation of operation.

Material

The material of which a gage is made is important. Porcelain is extremely hard and the abrasive action is considerable. A gage is expensive to make to a suitable accuracy, labor being the chief expense. When the type of thread is decided, a hard, tough steel capable of taking a glass-hard finish is desirable. Some of the gages have been specified as "tool steel, hardened" and "machine steel, case-hardened." Also there has been recommended "crucible, oil-hardened, non-shrinking tool steel" and other material under trade names which are difficult to reduce to terms suitable for an engineering specification. There are possibilities in processes recently developed for chromium plating over a comparatively soft, easily worked material.

Master Gage

As the insulator gage will wear down it is essential that ready means be available for checking it from time to time. A convenient type of master gage for that purpose is shown in Fig. 18. This is a ring gage with

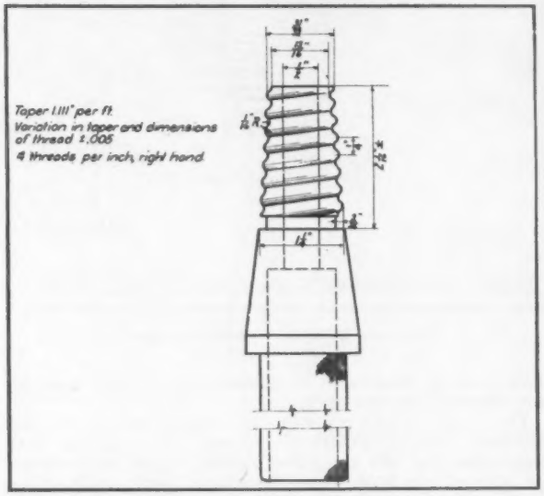


Fig. 17. Telephone and telegraph pin-hole gage.

accurately cut threads of the same type as the insulator gage and with a section cut out so the fit of the threads may be viewed. Accuracy will be indicated by the end of the insulator gage being flush with the face of the ring gage when the former is screwed into the latter. Overall wear will be indicated by the end of the insulator gage being flush with the face of the ring gage when the former is screwed into the latter. Overall wear will be indicated by the end of the insulator gage being admitted beyond the face of the ring gage, and local wear will be evident by noting the co-ordination at the threads.

Pins

The pins used by the power industry are of many types. The threads come under the following classes: Wood, lead thimble, spun metal filled with lead, cast metal cut to give spring action, pressed sheet metal, wire spring thread.

All of these types have been used with varying success and uniformity. The rigid metal thread often has given trouble by breaking insulators and many companies prefer a molded lead thimble in spite of higher cost than some of the other metal threads. Once the insulator thread is established, the pins readily can be made to conform.

Gaging of Pins

For a type of gage that will tell a great deal about a pin, Fig. 19 is suggested. The threads may be cut to the shape desired and the pin screwed in as far as it will go. The thread, pitch, taper and minimum diameter all may be checked by inspection.

The communication interests, confining their use to 1-in. pins and to wood almost exclusively, use rougher methods. Their pin gages are shown in Fig. 20, and it may be noted that smooth holes are used. These check taper and diameter while the flat gage shown has an edge which checks the pitch and shape of thread, as well as the general shape of the pin.

Present Status

Gages used by the Pacific Gas and Electric Company are satisfactory as far as they go. With the tolerances established the insulators purchased will fit satisfactorily on the present pins which have a full-rounded thread in lead, both ridge and valley having 1/16-in radius. The 1-in. insulators also receive the 1-in. wooden pins now purchased, but it is not known just how much greater tolerance may be permitted without adversely affecting the insulator fit on the pins. This company is not fully satisfied that it has the best type of pin thread for all insulators. All companies are getting along after a fashion under present conditions with the different threads existing. Rejects of one company go somewhere else and eventually are used.

It is believed that if a universal gage thread is decided upon and definite tolerances established the insulator manufacturers will not be averse to conforming to them.

Proposed Tests

It is proposed:

1. That gages be made up as detailed in Figs. 13 and 14.
2. That molds for lead thread be made up as detailed in Figs. 21 and 22.
3. That a considerable number of run-of-kiln porcelain insulators of each size be gaged and separated into groups varying by small differences (1/8 in.) in the depth to which they admit the gage (particularly outside of a medium range) for each type of gage thread.
4. That a number of metal pins be made up with lead threads (4 per cent antimony) from the molds, Figs. 21 and 22.
5. That the insulators of the various groups be tried out with the pins of different thread form under conditions similar to those in the field, and degree of fit noted.
6. That such tests be made at the factories of three or more representative companies producing insulators of the different types of thread in common use.
7. That from analysis of the results:
   (a) A standard type of gage thread be established by which 1-in. insulators should be graded.
   (b) A standard type of gage thread be established by which 1⅝-in. insulators should be gaged. (This may or may not be the same as found in (a) above.)

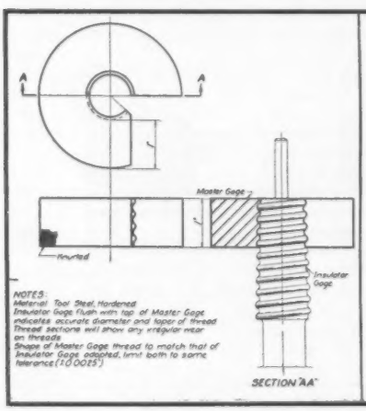

Master Gage
Knurled
Insulator Gage
NOTES:
Material: Tool Steel, Hardened
Insulator Gage flush with top of Master Gage indicates accurate diameter and taper of thread
Thread sections will show any irregular wear on threads
Shape of Master Gage thread to match that of Insulator Gage adopted, limit both to same tolerance (.0005")
SECTION "AA"

Fig. 18. Master for insulator pin-hole gages.

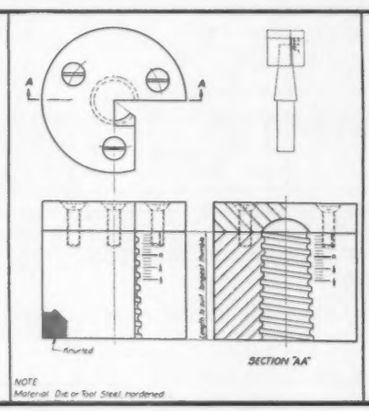


Fig. 19. Gage for insulator pins.

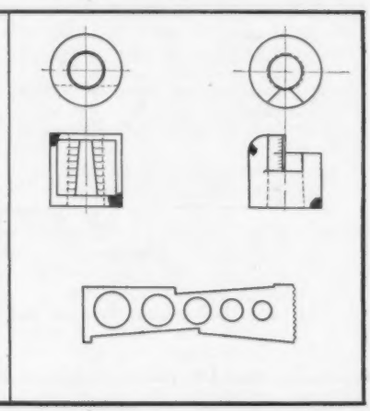


Fig. 20. Telephone and telegraph pin gages.

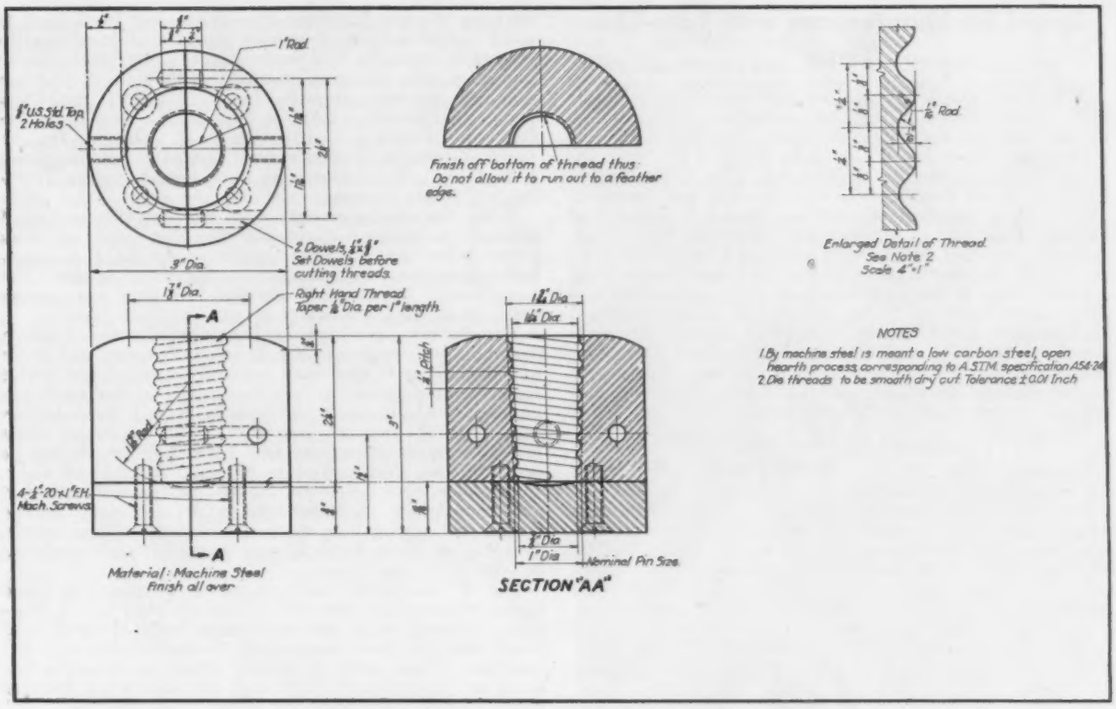

1" Rad.
1" U.S.Std. Tap. 2 Holes
2 Dowels, ½" x ¾" Set Dowels before cutting threads.
3" Dia.
1⅞" Dia.
Right Hand Thread Taper ⅛" Dia. per 1" length.
A
4-½"-20 x 1" F.H. Mach. Screws
Material: Machine Steel Finish all over
Finish off bottom of thread thus: Do not allow it to run out to a feather edge.
1¼" Dia.
1⅛" Dia.
⅝" Dia.
1" Dia.
Nominal Pin Size.
SECTION "AA"
Enlarged Detail of Thread. See Note 2 Scale 4" = 1"
NOTES
1. By machine steel is meant a low carbon steel, open hearth process, corresponding to A.S.T.M. specification A.S.4-24.
2. Die threads to be smooth dry cut. Tolerance ±0.01 Inch

Fig. 21. Die for casting 1-in., round -thread lead thimble on insulator pin.

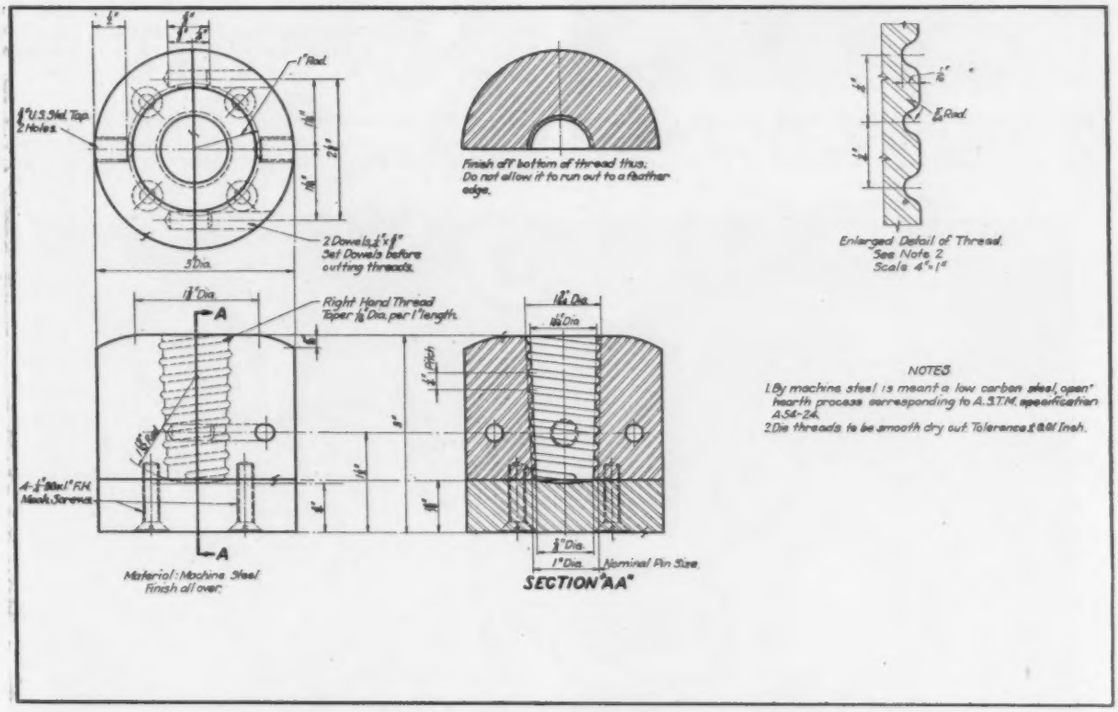

1" Rad.
1" U.S.Std. Tap. 2 Holes.
2 Dowels, ½" x ¾" Set Dowels before cutting threads.
3" Dia.
1⅞" Dia.
Right Hand Thread Taper ⅛" Dia. per 1" length.
A
4-½"-20 x 1" F.H. Mach. Screws
Material: Machine Steel Finish all over.
Finish off bottom of thread thus. Do not allow it to run out to a feather edge.
1¼" Dia.
1⅛" Dia.
⅝" Dia.
1" Dia.
Nominal Pin Size.
SECTION "AA"
Enlarged Detail of Thread. See Note 2 Scale 4" = 1"
NOTES
1. By machine steel is meant a low carbon steel, open hearth process corresponding to A.S.T.M. specification A.S.4-24.
2. Die threads to be smooth dry cut. Tolerance ±0.01 Inch.

Fig. 22. Die for casting 1-in., beaded thread lead thimble on insulator pin.

(c) A suitable type of thread for lead thimbles for each size of pin be recommended.

(d) The maximum tolerances permissible in gaging each size of insulator be established, together with the recommended gage which will permit satisfactory mounting of the insulator on the pin.

8. Generally the tests should include limits for obliquity, varied tolerances for different depth of pin hole, tests with wooden pins, with other types of metal pins, etc. The most pressing problem is that of the 1⅜-in. insulator for the voltages of from 30 to 80 kv.

The above report was presented at the January meeting of the P.C.E.A. overhead systems committee with the request that funds be made available for the completion of the investigation, as it was felt that the expense should be distributed among the member companies. The action taken was a recommendation that the report be referred to the national body for completion as it involved the whole industry and not alone a local section.

Live-Line Maintenance with Live-Line Tools*

When the study of this subject was undertaken in 1925 by the insulator test subcommittee practically all of the P.C.E.A. member companies were using live-line maintenance methods on voltages below 5-kv. with the usual rubber protective equipment. The San Joaquin Light & Power Corporation was the only one, however, that made a practice of working lines hot above that voltage. Most of the others using 11-kv. or higher distribution were of the opinion that such work would be necessary at some future time. The San Diego Consolidated Gas & Electric Company had made some use of live-line tools on 11-kv. lines, but found workmen antagonistic to their use. Several companies were using hot-tap devices to obviate interruptions when connecting new consumers to existing lines. Others reported duplication of lines or the sectionalizing of loop systems as methods used to minimize shut-downs.

Recent Developments

The study this past year has been devoted to operating experiences in live-line maintenance with voltages higher than 5-kv. and to the tools with which such maintenance work is accomplished. During the present year there has been an increase of the companies using live-line tools. The Southern California Edison Company has equipped six of its districts with tools, the San Joaquin Light & Power Corporation has extended their use. Live-line tools also are being used to some extent by The Southern Sierras Power Company, The Ontario (Calif.) Power Company, City of Los Angeles, City of Riverside, U. S. Bureau of Yards and Docks, Mare Island, the Great Western Power Company and the San Diego Consolidated Gas & Electric Company. Considerable use of such tools in other parts of the country was shown by the N.E.L.A. report of last year.

Following are reports from three companies on the use of live-line maintenance:

Tools Used

Several lines of hot wire tools are on the market. Most of them consist of various metal heads carried on long wooden handles. Also there has been used to some extent a type of wooden shield that insulates the workman from the live parts, much as rubber blankets, line hose, etc., are used on lower voltage lines. The former type are manufactured by W. T. Safety Tool Company, Inc., Decatur, Illinois; The Safety Live-Line Tool Company, Oakland, California; T. F. Johnson, Jr., Atlanta, Georgia; Transelectric Company, Indianapolis, and others. The latter type have been supplied by the Bush Electric Company of Cleveland, Ohio.

With the single exception of the San Diego Gas & Electric Company, all of the live-line work on lines above 5-kv. that has been reported by P.C.E.A. member companies has been done with the "Safety Live-Line Tools." These tools are the ones that were developed on the San Joaquin system.

The Safety Live-Line Tools, as before stated above, are mounted on insulating handles. Handles are made of selected wood and very carefully treated and tested for dielectric strength. As the safety of the workman depends entirely upon the handle it is a most important part of any live-line tool. The heads of these tools are quite ingenious and with them work can be accomplished that cannot be detected from hand work. These tools were developed for distribution voltages, but are now being manufactured with sufficient handle length and strength to work almost any voltage safely. A group of these tools as now manufactured is shown in Fig. 1.

The W. T. Safety Tools to which reference is made in the report of the San Diego Consolidated Gas & Electric Company also are insulating handled tools and great care has been devoted to the manufacture of the handles. They were developed more particularly for work on high-voltage lines and are somewhat heavier than the tools developed for distribution-line use.

The Bush Company manufacture the wooden guards previously referred to as well as the Bush hot-tap machine and Bush wire cutter. These latter tools are used extensively by some of the member companies and are reported as satisfactory for the use for which they are intended. The treated wooden shields, ladders, etc., that are furnished by this company for use on hot lines have not been used by any P.C.E.A. company reporting.

Conclusion

That live-line maintenance of distribution lines has proven very advantageous to those companies using it is shown by the following reports. The growing

* **Report of sub-committee.—H. H. Minor, chairman.** R. G. Boyles, H. L. Caldwell, R. S. Daniels, E. N. D'Oyly, A. S. Glasgow, G. H. Hagar, C. B. Judson, H. H. Miller, R. W. Muller, R. C. Seagren, D. D. Smalley, A. E. Strong, A. J. Theis, C. W. Walker.

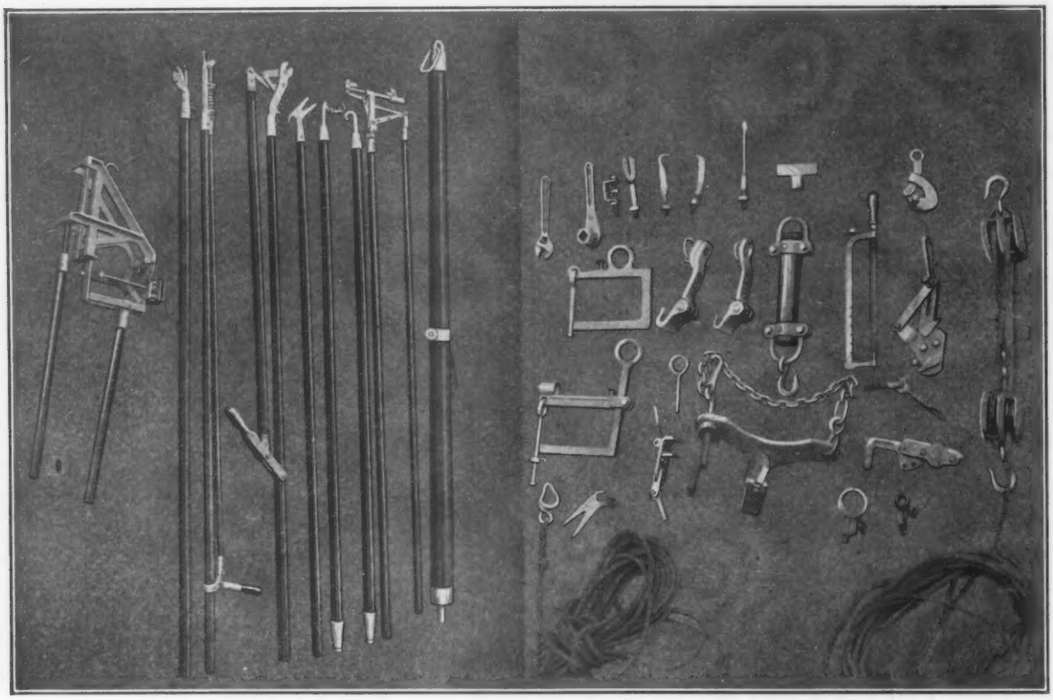


Fig. 1. Complete set of safety live-line tools now used by San Joaquin Light & Power Corporation.

necessity of continuous service on all lines and the increasing use of higher distribution voltages make it more and more difficult to give such uninterrupted service without live-line maintenance. Many companies have delayed adopting such methods because of the hazard involved. Experiences of P.C.E.A. companies reporting, as well as of those in other parts of the country using live-line methods prove that with proper tools and careful supervision of the work the hazard to the workmen largely has been eliminated. In other localities it has been found advisable to use live-line maintenance methods for the higher voltage transmission lines as well as for distribution lines. This probably will be advisable on the Pacific Coast for some lines. The great need at present, however, is to limit distribution-line interruptions as much as possible.

Transmission systems, through parallel lines, loop arrangement, etc., and proper relay protection do not often cause an interruption to a distribution substation. When repairs are necessary on such lines they can be killed readily without dropping load. With distribution lines or single-feed transmission lines this usually is not the case and to kill them means a service interruption. The goal toward which all are striving is perfect service to the consumer. That means uninterrupted service at all times and it seems that the one way of approaching that goal is to adopt live-line maintenance methods with the proper tools and close supervision.

Hot-Line Tool Experience on the San Joaquin System

By H. H. MINOR

Live-line maintenance of 11-kv. distribution lines has been carried on by the San Joaquin Light & Power Corporation for more than three years. Prior to that time all such lines were killed when work was to be done on them. Connecting new consumers to existing lines by the use of a hot-tap machine has been tried with some success, but its use was limited to rather small wire sizes and proved somewhat hazardous in many locations. Temporary tap devices also were tried, but the difficulty of finding an opportune time to kill the line later to retrieve

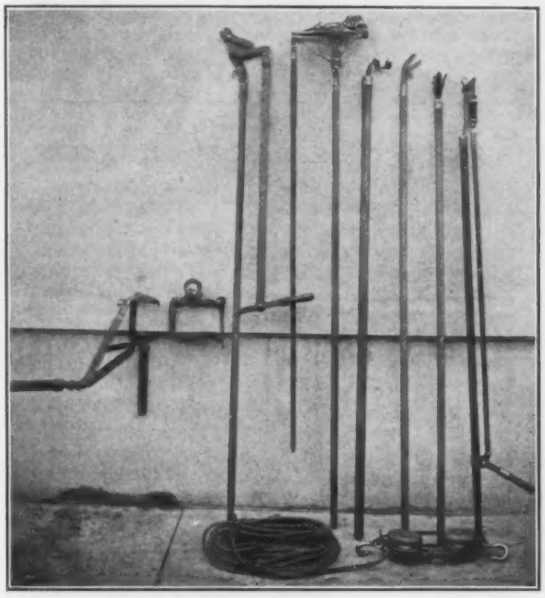


Fig. 2. Original set of live-line tools used by live-line crew of San Joaquin Light & Power Corporation.

the temporary taps resulted in many staying on the lines for months. Interruptions to service were necessarily becoming more and more frequent as the load density increased. Also at about that same time a certain type of dead-end insulator that had been in service for a few years was beginning to fail and the company was confronted with the problem of replacing several thousand of such units. This would have meant extreme service interruptions under the plan of operation then in vogue.

The limited application of the hot-tap machine and the many maintenance jobs that were causing interruptions led C. C. Coon, then maintenance foreman, to experiment with some simple tools with which he could accomplish such jobs with the lines energized. After much thought and many trials, the result was the set of "live line tools" shown in Fig. 2.

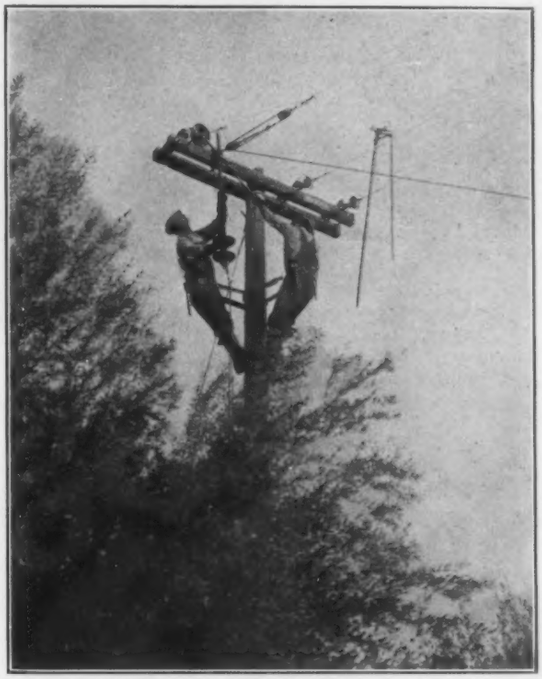


Fig. 3. San Joaquin crew replacing 11-kv. dead end on a live line.

A live-line crew consisting of Mr. Coon, a lineman and groundman was put to work in the Fresno district. From the start the operation of this crew was very carefully watched and a record kept of work accomplished. The improvement in operating conditions and the reduced number of interruptions was so marked that it was decided to equip a like crew for each of the districts of the system. Mr. Coon was put in charge of all live-line work. His duties consisted of instructing the men in the use of the tools, seeing that the equipment was kept in proper repair and that at all times safety was given first consideration.

The live-line crews, two linemen and one groundman, thus established in each district, handled all of the "hot work" except that on 2-kv. lines which was done by a regular line crew equipped with rubber protective devices. When new taps were to be made on existing lines the line crew built the new tap and connected it to the hot line by a temporary hot tap. This was reported to the district office and the live-line crew made this temporary tap permanent. When possible, several such jobs in the same vicinity were bunched so as to save time and mileage. In addition to this they worked in conjunction with line crews when setting new poles in lines or other similar jobs. They also did most of the patrolling of distribution lines, usually repairing as they went, and helped out in such work as inspecting transformers, clearing radio troubles, etc. It soon developed that there was more such work in most of the districts than one crew could handle, particularly during the "new business peak" when there were a great many new extensions to be connected to hot lines. Therefore, early in 1926 each regular line truck was equipped with enough of the tools, and men trained in their use, so that they could make their own hot taps. This resulted in a big saving of time for the live-line crews and also saved duplication of mileage in completing jobs started by the line crew.

The set of tools originally used was added to and changed from time to time as experience developed improvements. At first only such jobs as replacing pin-type or strain insulators, making hot taps, etc., were attempted. Before long, however, almost any kind of a job that could be done at all was being accomplished with the lines energized. This included

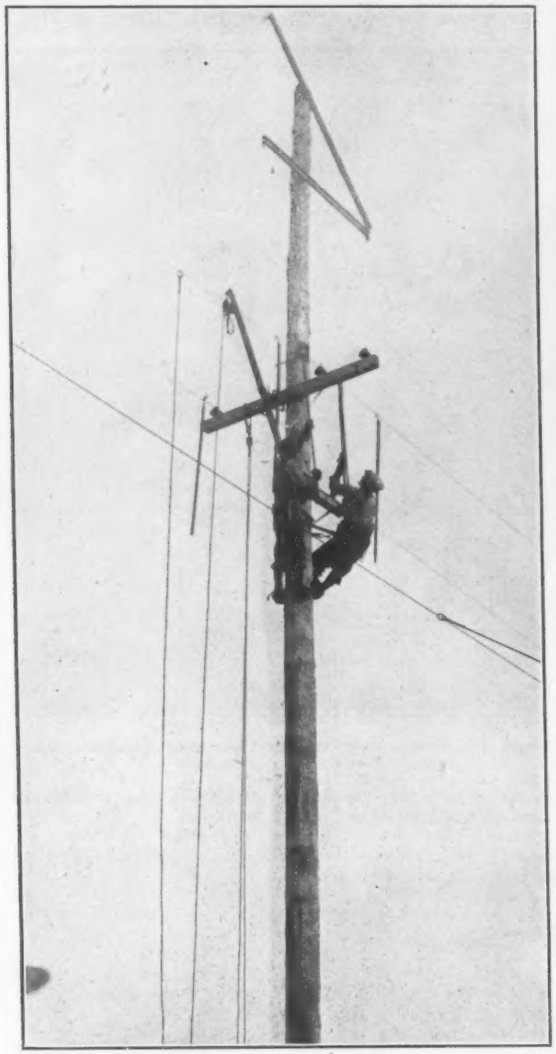


Fig. 4. San Joaquin crew tying in a live 11-kv. line on a transmission pole.

such jobs as replacing air switches, changing pin-type dead ends to strain-type and many other seemingly impossible jobs. A complete set of tools such as is now used by the San Joaquin live-line crews consists of some 25 items. A "hot-wire demonstration" at Fresno during the 1926 Engineering Section gathering is shown in Figs. 3 and 4.

The live-line crews are equipped with a commercial-type car fitted with tool boxes for the equipment. Care is taken that the tools shall be kept dry and the handles are protected from abrasion as much as is possible. The Bakersfield "hot wire wagon" is shown in Fig. 5. Enough spare material such as insulators, bolts, wire, etc., is carried to facilitate emergency repairs at any time.

As stated before, safety has been stressed in the design of the tools and in their maintenance as well as in the instruction of the men using them. Handles of all tools are re-shellaced every month and every six months they are tested for dielectric strength and re-treated if necessary. This maintenance of the tools is watched very closely and that it has received proper attention is proved by the operating record. There has not been an accident that in any way can be charged to the failure of the tools. There has been only one accident to a workman engaged in live-line work on the San Joaquin system and that was due entirely to his own carelessness. He contacted a hot wire with one hand while his leg was against a phone lead, resulting in a burn on his hand and leg. He should not have been in a position that made it possible for him to reach the hot line and the phone line should have been dropped out of his way. While it is most regrettable that the accident occurred, it served to emphasize the necessity of continued care and watchfulness by the men themselves and by those in charge of the work so that the safety rules are not broken for any reason.

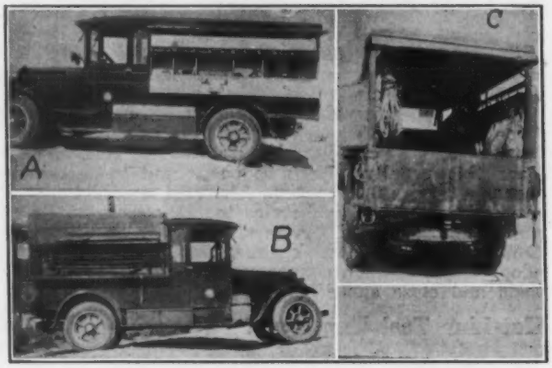


Fig. 5. San Joaquin live-line maintenance truck. (A) Showing compartments for miscellaneous small tools and material. (B) Box for tools with long insulating handles. (C) Interior of truck, ample room for hand lines, blocks and bulky material.

It never has been difficult to get linemen to undertake the live-line work on the San Joaquin system. Usually there is a waiting list in all districts for a chance to get on one of the crews. The fact that the work is interesting, somewhat lighter than regular line work and that the crew is small and the men work more or less "on their own" probably is the reason. The work commands the same pay as regular line work.

From the first a very complete record has been kept of routine live-line work. These reports are recapitulated monthly and yearly in the distribution superintendent's office. They show not only the live-line work accomplished, but also show the time consumed in doing such work and the miles traveled. Also an estimate of the time and mileage that would have been required to do the same work with the lines killed; the number of transformer banks that would have been interrupted, and the switches it would have been necessary to operate are included in the job reports. The transformer and switch data

TABLE NO. I.
REPORT OF LIVE LINE WORK S.J.L.&P. CORP.

LIVE LINE WORK ACCOMPLISHED	1925	1926	TOTAL
STRAIN INSULATORS CHANGED	5139	6317	11456
PIN INSULATORS CHANGED	699	773	1472
FUSE INSULATORS CHANGED	214	247	461
BROKEN PINS REPLACED	211	251	462
JUMPERS PLACED	5306	8495	13801
PIN DEADENDS MADE STRAIN	90	107	197
POLES SET IN LINES	812	1136	1948
MILEAGE FOR ABOVE	35146	48561	83707
CREW HOURS FOR ABOVE	4983	6771	11754
NECESSARY IF LINES WERE KILLED			
TRANSF. BANKS KILLED	77990	131257	209247
SWITCHES TO OPERATE	5520	8838	14358
MILEAGE NECESSARY	66223	105147	171370
CREW HOURS NECESSARY	9555	93128	22683

	SAVING	
INTERRUPTIONS	209247	TRANSFORMER BANKS
SWITCHING	14358	OPERATIONS
MILEAGE	87663	MILES
LABOR	10929	CREW HOURS

represent an actual count from the distribution maps and therefore is quite correct. The mileage and time estimate is based only upon the additional time and distance necessary to do the switching required to kill the section of line to be worked on. Table I shows the totals from these reports of the San Joaquin system, not including the Midland Counties Public Service Corporation, for the years 1925 and 1926. These figures show better than anything else that live-line maintenance on the San Joaquin system has been a success. That the work is justified is shown by the 209,247 banks of transformers upon which interruptions were saved during two years as well as by the saving of 87,663 miles and 10,929 crew hours to accomplish the work done. To return to the old methods of killing lines would be a step backward in the estimation of the company, the men and the consumers.

Hot-Line Tool Experience on the System

By A. S. GLASGOW

The San Diego Consolidated Gas & Electric Company uses the following set of hot line tools: long wire tongs, small wire tongs, safety hand poles, hand pole mirrors, Bell dead end set, safety wire cutters, safety link poles, wedge wire pullers, safety butt straps, safety tool sacks, and insulated poles. In addition, a "Jackson stick" is used for making hot-line taps. This tool has been described completely in papers previously published.

Experience of this company with hot-line tools is quite limited for several reasons. Most lines are so arranged that any portion in need of repairs may be killed easily. On sections which cannot be so handled it is considered unsafe to attempt much hot-line work because of the close proximity of lines to the seacoast. The sea atmosphere results in making the poles more or less conducting and necessitates a more solid connection than is possible with the live-line tools. In such cases the line simply is shut down at a time convenient for repairs. Occasionally however, it is necessary to keep the lines going and at such times the hot-line tools are used.

A great deal of difficulty has been encountered in linemen antagonistic to the use of hot-line tools. In spite of anything the company can do it seems impossible to make any satisfactory headway with them.

Hot-Line Tool Experience on the Southern California Edison Company System

By R. G. BOYLES

Five districts in the San Joaquin Valley and one district in the south are equipped with sets of tools.

So far the use of these tools has been successful and the districts so equipped are well pleased with the results. There are certain small jobs which any crew might be called upon to perform and hence it is believed that it would be advisable to equip all trucks with certain tools to permit emergency work by any crew in the field. It is not believed that the company would be justified in equipping all gangs with complete sets of tools.

As the service demands become more exacting some method must be devised to render continuous service and it would appear that live-line maintenance will be a great help in accomplishing this result.

Miscellaneous Experiences with Hot-Line Tools

C. C. Coon, formerly in charge of live-line work for the San Joaquin Light & Power Corporation and now engaged in the manufacture of live-line tools, reports, among others, the following cases of hot work done while demonstrating the use of his tools or instructing purchasers in their use:

Central Texas Light & Power Company.—Center string of a vertical corner on a 78-kv. line, consisting of eight ball-and-socket type units, was changed in 40 minutes. Eleven suspension strings on a 78-kv. line were changed in an afternoon.

Bureau of Power & Light, Los Angeles.—Six pin-type insulators changed on a 33-kv. line in two hours, part of which time was spent in instructing the men.

The Southern Sierras Power Company.—A 45-ft. pole was set in a 35-ft., 30-kv. 4/0 lead and the wire tied in on the new pole.

Construction and Operation of 220-kv. Lines*

This paper deals with the following subjects:

Summary

1. General statement of 220-kv. lines now in existence.

2. Tabulation of data on existing lines and other lines that will be operating at 220 kv. in the near future: (a) general data, (b) tower data, (c) tower design loads.

3. Outline of successive steps of office and field work in locating towers and stringing cable for a 220-kv. line.

4. Tests to determine the amount of stretch in transmission line cables.

5. Studies on insulators for 220-kv. lines.

6. Operating experience.

7. Bibliography of writings on 220-kv. transmission.

1—Present 220-kv. Lines

Transmission lines that now are in operation at 220-kv., the Pit River line of the Pacific Gas and Electric Company, the Big Creek lines of The Southern California Edison Company, and the Wallenpaupack-Siegfried line of the Pennsylvania Power and Light Company, have been completely described in the reports of the N.E.L.A., P.C.E.A. and in the technical press in general. For this reason it is unnecessary to include these descriptions in this report except as they appear in the bibliography.

2—Tabulation of 220-kv. Line Data

General information, tower data, and tower design loadings are given in Table I, II and III respectively.

3—Field and Office Work

Successive steps in field and office work incident to 220-kv. line construction are given in the following outline:

This description was written to cover the procedure followed by one company. Other companies use practically the same methods.

1. Fundamental Assumptions—All office calculations are based on the catenary curve. For this purpose the Thomas chart was amplified to cover spans at various degrees of slope. All spans have equal tensions at an average temperature, rather than equal maximum tensions.

2. Preliminary Tower Locations—Profile furnished by surveying department, scale in. =200 ft. horizontally and 40 vertically. Towers located by template at 130 deg. sags and points of critical clearance noted.

3. Field Checking—At each tower location ground elevations for each leg are obtained together with slope of ground. Cross-sections are taken at all points of critical clearance.

4. Final Office Location of Towers—Extension and grade for each tower is determined, to give required cover of footings. Clearances are checked for up-hill wire in every case. In general, cuts are eliminated by additional extensions.

5. Office Calculations for Towers—Vertical wire load (double string of suspension insulators specified if load is greater than 6,000 lb.) Swing of insulators across line (tie-down specified if clearance to steel is less than 4 ft. 6 in. **For spans**—Curves for maximum tensions and for maximum sags. (In these calculations allowance was made for a 0.04 per cent stretch in the wire after stringing.) **For stringing**—Tensions at different temperatures chosen for each section of line and such that maximum tensions would be within specified limits and required ground clearances at 130 deg. F. would be obtained. Since line was to be sagged in, and since parabolic formulas are simplest for field calculations, correction curves were plotted for converting parabolic to catenary sags.

6. Data Sheets Prepared; Tower Sheets—Showing type of tower extension, footing extension, grade, station, type of insulation, horizontal angle, span. **Cut Sheets**—Showing elevation of pipe set at center of each tower, and cuts for each footing. **Stringing Data**—Showing length of wire in each span; length of wire when through sheaves, but lying on ground between towers; totals of above lengths for different sections; horizontal stringing tension for different sections; vertical stringing loads. **Sag Stakes**—Showing elevations for setting sag stakes in all spans where sag was greater than tower height.

7. Final Field Work—Surveying department staked towers for footing excavation and set footings to required grade. Sag stakes set where required. Engineering department supervised wire stringing, recording sags to which individual spans were strung.

8. Final Check Measurement—Sags are being measured in various typical spans and at irregular intervals to determine the actual amount of stretch occurring in the wire.

4—Tests to Determine Conductor Stretch

Experience with steel-reinforced aluminum cable has shown that considerable stretch occurs in the cable after it is installed. Attempts have been made to allow for the stretch, so that the cable would hang finally in the desired position, by stringing to a somewhat less sag or greater tension than that finally expected for the temperature existing at the time of stringing, or by pulling the conductor to the elastic limit and slacking it back to the final tension desired for that temperature.

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* **Report of sub-committee.—H. Michener, chairman.** C. F. Andrews, C. F. Benham, N. P. Carlsen, F. R. George, C. E. Heath, W. D. Skinner, E. H. Steele, H. W. Tice, Roy Wilkins.

TABLE I.—GENERAL LINE DATA

Column Number	Southern California Edison Company Vincent Long Beach 1	2	Pacific Gas and Electric Company Pit River 3	4	Great Western Power Company 5	6	Pennsylvania Power and Light Company Wallenpaupack 7
Circuits on Tower	1	2	2	1	2	1	1.
Length—Miles	223.5	9	141.64	27.56 Aluminum 32.34 Copper	172	50	65.
Average Span	1,320 ft.	850 ft.	800 ft.	550 ft. Aluminum 500 ft. Copper	850 ft.	650 ft.	1,108 ft.
Maximum Span	5,191 ft.	1,360 ft.	1,630 ft.	1,802 ft.	1,332 ft.	1,537 ft.	2,400 ft.
Conductor	A.C.S.R. 1,033,500 CM.	Cop. and Bronze 650,000 CM.	A.C.S.R. 518,000 CM. Copper 500,000 CM.	A. C. S. R. 795,000 CM.	A. C. S. R. 795,000 CM.	A. C. S. R. 795,000 CM.	A. C. S. R. 795,000 CM
Insulators	10-in. Cap and Pin	10-in. Cap and Pin	Cap and Pin	10-in. Cap and Pin	10-in. Cap and Pin	10-in. Cap and Pin	Cap and Pin.
Kind	Suspension	Suspension	Suspension	Suspension	Suspension	Suspension	Suspension.
In Susp. String	13	15	13-10 and 14-in.	13-10 and 14-in.	14	14	14.
In dead-end String	2 x 15.	2 x 15.	12-11 and 13½-in.	12-11 and 13½-in.	16-11-in. cap and pin	15-11-in. cap and pin	3 x 16.
Loadings							
Light Temp.	25-deg. F.	25-deg. F.	10-deg. F.				
Light Wind	8 lb. per sq. ft.	8 lb. per sq. ft.	9 lb. per sq. ft.				
Med. Temp.					20-deg. F.		0-deg. F.
Med. Wind					15 lb. per sq. ft.		8 lb. per sq. ft.
Med. Ice							1-in. Radial.
Heavy Temp.	0-deg. F.			10-deg. F.		0-deg. F.	0-deg. F.
Heavy Wind	6 lb. per sq. ft.			8 lb. per sq. ft.		8 lb. per sq. ft.	8 lb. per sq. ft.
Heavy Ice	½-in. radial			½-in. radial		½-in. radial	1½-in. radial.
Clearances—Minimum							
To Ground—							
General	30 ft.	35 ft.	30 ft.	30 ft.	30 ft.	30 ft.	30 ft.
Special	Inaccessible locations—25 ft.	Broken wire over roads—50 ft.	Min. over R. R. 31 ft.				Inaccessible Locations—25 ft.
To Tower—							
Design load	6 ft. 0-in.	6 ft. 0-in.			5 ft. 0-in.	6 ft. 6-in.	
Minimum load	4 ft. 6-in.	6 ft. 0-in.	4 ft. 6-in.	4 ft. 6-in.	5 ft. 6-in.	5 ft. 9-in.	4 ft. 6-in.
Between Phases—							
Vertical		20 ft.	15 ft.		16 ft. 0-in.	Triangular	22 ft. 7½-in.
Horizontal	22 ft. 3-in.			19 ft. 0-in.		27 ft. base 21 ft. to apex	
Between Circuits		28 ft.	24 ft.		27 ft. 4-in.		

TABLE III.—TOWER DESIGN DATA

Column Number	Southern California Edison Company Vincent Long Beach 1	2	Pacific Gas and Electric Company Pit River 3	4	Great Western Power Company 5	6	Pennsylvania Power and Light Company Wallenpaupack 7
Standard Towers	For 10-deg. angles and 2,500 ft. spans	For 4-deg. angles and 1,500 ft. spans	For 1,000 ft. spans	For 750 ft. spans	3½-deg. angles and 850 ft. spans	10-deg. angles and 1,600 ft. spans	
Conductor tension	8,000 lb. x 2.	10,000 lb. x 2.	4,500 lb. x 3.	4,350 lb. x 3.	7,000 lb. x 3.	7,000 lb. x 3.	10,000 lb.
Vertical wire load	6,000 lb. x 3.	3,000 lb. x 2. 6,000 lb. x 4.	1,600 lb. x 6.	3,500 lb. x 3.	3,000 lb. x 6.	6,000 lb. x 6.	14,000 lb.
Wind on wire	2,800 lb. x 3.	600 lb. x 2. 1,200 lb. x 4.	500 lb. x 6.	1,000 lb. x 3.	1,160 lb. x 3.	With ice 2,230 lb. x 3.	1,100 lb. x 3.
Wind on tower	13 lb. per sq. ft. on 1½ area	13 lb. per sq. ft. on 1½ area	15 lb. per sq. ft. on 1½ area	15 lb. per sq. ft. on 1½ area	19½ lb. per sq. ft. on each side	19½ lb. per sq. ft. on each side	1,000 lb.
Transverse pull	2,100 lb. x 3.	400 lb. x 2. 800 lb. x 4.			13,200 lb.	5,900 lb. x 3.	8,400 lb.
Grnd. wire pull		3,600 lb.			None.	None.	None.
Grnd. wire weight	3,000 lb.	1,000 lb.					
Grnd. wire wind load	1,000 lb.	600 lb.					
Grnd. wire transv. load	1,200 lb.	200 lb.					
Anchor Towers	For 30-deg. angles and 2,500 ft. spans	For 30-deg. angles and 1,200 ft. spans	For 22½-deg. angles and 800 ft. spans	For 22½-deg. angles and 1,000 ft. spans	45-deg. angles and 850 ft. spans	50-deg. angles and 700 ft. spans	
Conductor tension	12,000 lb. x 3.	13,400 lb. x 6.	6,800 lb. x 6.	7,000 lb. x 3.	10,500 lb. x 6.	10,500 lb. x 3.	29,000 lb. x 3.
Vertical wire load	6,000 lb. x 3.	6,000 lb. x 6.	On tangent 2,000 lb. x 6. On angles 950 lb. x 6.	4,200 lb. x 3.	3,000 lb. x 6.	6,000 lb. x 3.	29,000 lb. x 3.
Wind on wire	2,800 lb. x 3.	1,000 lb. x 6.	400 lb. x 6.	1,300 lb. x 3.	1,160 lb. x 3.	1,000 lb. x 3.	3,000 lb. x 3.
Wind on tower	13 lb. per sq. ft. on 1½ area	13 lb. per sq. ft. on 1½ area	15 lb. per sq. ft. on 1½ area	15 lb. per sq. ft. on 1½ area	19½ lb. per sq. ft. on each side	19½ lb. per sq. ft. on each side	1,000 lb.
Transverse pull	6,200 lb. x 3.	7,000 lb. x 6.	2,650 lb. x 6.	2,750 lb. x 3.	18,180 lb.	10,870 lb. x 3.	35,000 lb.
Grnd. wire pull	7,000 lb.	3,600 lb.					
Grnd. wire weight	3,000 lb.	1,000 lb.					
Grnd. wire wind load	1,000 lb.	600 lb.					
Grnd. wire transv. load	3,600 lb.	1,400 lb.					

TABLE II.—TOWER DATA

	Southern California Edison Company Vincent Long Beach		Pacific Gas and Electric Company Pit River		Great Western Power Company		Pennsylvania Power and Light Company Wallenpaupack
Column Number	1	2	3	4	5	6	7
Standard Towers							
Maximum angle	11-deg. 40-min	5-deg. 30-min	None	None	3-deg	10-deg	A-tower 1½-deg.
Height—overall	68 ft. 0-in	124 ft. 0-in	97 ft. 0-in	55 ft. 6-in	100 ft. 4 ¼-in	79 ft. 8-in	None.
Height—to wire	55 ft. 4-in	71 ft. 2-in	55 ft. 0-in	44 ft. 6-in	55 ft.	48 ft.	65 ft. 7-in.
Base	24 x 24 ft.	24 x 24 ft.	20 x 20 ft.	20 x 20 ft.	24 x 24 ft.	16 x 16 ft.	
Weight	8,886 lb.	12,000 lb.	8,100 lb.	4,850 lb.	3,395 lb.	6,700 lb.	7,730 lb.
Extensions							
Level	7, 14, 21 ft.	30 ft.	2½, 5, 7½, 15½, 25½ ft.	2½, 5, 7½, 12, 20, 25 ft.	10, 25 ft.	3, 6, 9, 12 ft.	5, 10, 15, 20 ft. in any combination.
Side-hill	7, 14, 21 ft.		2½, 5, 7½ ft.	2½, 5, 7½ ft.	5 ft.	3, 6, 9, 12 ft.	
Combination	Up to 35 ft.		Up to 33 ft.	Up to 37½ ft.	None	Up to 12 ft.	
Footings	Steel pyramid	Pyramid in concrete, some on piles	Steel and reinforced concrete		Steel grillage	Steel grillage	Modified malone.
Depth	8 ft.		7 ft. 6-in.	7 ft. 3-in.	9 ft.	7 ft. 9-in.	9 ft.
Base	4 x 4 ft.		4 ft. 6-in. x 4 ft. 6-in.	4 ft. 6-in. x 3 ft. 9-in.	3 ft. 6-in. circular	3 ft. 6-in. x 3 ft. 6-in.	
Weight of four	2,044 lb.		330 lb. + 256 lb. Re-inf. + 7.8 cu. yd. concrete.	250 lb. + 340 lb. Re-inf. + 6.28 cu. yd. concrete	1,430 lb.	1,980 lb.	560 lb. and concrete.
Extension	2 ft. units				None	None	
Weight of ext.	183 lb.						
Anchor Towers							
Maximum angle	36-deg. 45-min.		22-deg. 30-min.	22-deg. 30-min.	45-deg.	50-deg.	Large angles.
Height—overall	60 ft.	115 ft.	92 and 98 ft.	55 ft. 6-in.	99 ft. 1¼-in.		3 poles.
Height—to wire	46 ft.	71 ft.	57 and 63 ft.	51 ft. 6-in.	62 ft.	48 ft.	66 ft. 0-in.
Base	24 x 24 ft.	24 x 24 ft.	20 x 20 ft.	20 x 20 ft.	24 x 24 ft.	16 x 16 ft.	
Weight	13,602 lb.	24,000 lb.	11,270 lb.—92 ft. 12,010 lb.—98 ft.	6,850 lb.	12,360 lb.	5,847 lb.	11,000 lb.
Extensions							
Level	7, 14, 21 ft.	30 ft.	2½, 5, 7½ ft.	2½, 5, 7, 12, 25 ft.	10 ft.	3, 6, 9, 12 ft.	5 ft. units.
Side-hill			2½, 5, 7½ ft.	2½, 5, 7, 12 ft.			
Combinations				Up to 45 ft.		Combinations	
Footings	Steel pyramid	Pyramid in concrete, some on piles	Steel in reinforced concrete	Steel and reinforced concrete	Steel grillage	Steel grillage	Steel and concrete.
Depth	9 ft.		8 ft. 6-in.	7 ft. 0-in.	11 ft. 6-in.	7 ft. 9-in.	4 ft.
Base	6 ft. 6-in. x 6 ft. 6-in.		7 ft. 9-in. x 7 ft. 9-in.	7 ft. 6-in. x 7 ft. 9-in.	3 ft. 6-in. x 4 ft.	3 ft. 6-in. x 3 ft. 6-in.	4 x 4 ft. each.
Weight	6,720 lb.		940 lb. + 1,540 lb. reinf. + 15.2 cu. ft. concrete.	420 lb. + 1,930 lb. reinf. + 11.8 cu. yd. concrete	3,280 lb.	1,980 lb.	5,700 lb. inc. guys.
Special Towers							
Kind		90-deg. angle	High Crossings		Crossings		3 types for long spans and small angle.
Height—overall		175 ft.	194 ft. Max.		167 ft. 4½-in.		
Height—to wire		131 ft.	147 ft.		105 ft.		65 ft. 7-in.
Base		40 x 40 ft.	40 x 40 ft.		24 x 24 ft.		
Weight		35,000 lb.	49,870 lb.		17,628 lb.		16,600 to 21,200 lb.
Footings		Concrete on Piles	Concrete block with or without piles		Steel and concrete		Modified malone.
Weight of four			1,330 lb. + anchor bolts + 133 cu. yd. concrete		3,280 lb.		800 to 1,000 lb. + concrete.

Whether or not either of these methods will give the desired results has not been determined as yet.

In considering the proper procedure to be followed in stringing the 1,033,500-circ-mil. cable on the Vincent line of the Southern California Edison Company it was reasoned that such a cable loaded to a definite tension would stretch a definite amount during a definite time and then would stretch no more so long as that definite tension was not exceeded; that is, its length under the same temperature and tension would remain constant. If this amount of stretch could be determined for the tension that would exist in the cable over a long period of years in actual service, then the conductor could be shortened by that amount at the time of installation, and after the long period of years had passed it would hang in the desired position. Also it was thought that the modulus of elasticity of the cable would change as the stretch took place.

To determine these points four spans of this cable each approximately 1,060 ft. long were installed with means for carefully measuring tensions, cable lengths and temperatures. One of the spans also was provided with means for lowering it to the ground and pulling it up again whenever desired.

Spans A, B and C were pulled to tensions ranging between 8,500 lb. and 9,000 lb. at 85 deg. F. and left in that condition, the only variations being those due to stretch, temperature changes and wind. As each 1,000 lb. increment of tension was added, readings of tension, length and temperature were taken. Span D was pulled to 8,000 lb. and then because of a mistake in the length of the cable it was left over night and the next morning slacked to the ground, the length corrected and then pulled to 12,000 lb. and slacked to 11,000 lb. where it was left. At irregular intervals ranging from 7 to 25 days, Span D was slacked to the ground, pulled up to 12,000 lb. and back to 11,000 lb. again, measurements of tension length and temperature being taken for each 500-lb. change in tension.

Stress-strain diagrams were plotted for all spans from data obtained when first pulled up and for Span D every time it was lowered to the ground and pulled up again.

The moduli of elasticity for spans A, B and C and for span D the first time it was pulled up to 8,000 lb. ranged from 7,560,000 to 7,950,000 lb. per sq. in. and averaged 7,810,000 lb. per sq. in. This value was so near the 7,750,000 lb. per sq. in. which previously had been given by the Aluminum Company of America that the latter figure was adopted for the temporary modulus of elasticity. After span D had hung at about 8,000 lb. over night, the modulus of elasticity obtained by lowering it to the ground and pulling it up to 12,000 lb. was 9,040,000 lb. per sq. in. On the several times that span D was lowered to the ground from its approximately 11,000-lb. tension and pulled up again, the moduli of elasticity ranged from 11,000,000 to 9,500,000 with an average value of 10,000,000 lb. per sq. in., but since the higher values came from the earlier tests, 9,800,000 lb. per sq. in. was chosen as the permanent modulus of elasticity for this cable.

In addition to the measurements taken on span D as described above, recording dynomometers on spans A, B and C gave a record of the tensions in those spans and the lengths were measured about every week. The length measurements showed a progressive stretching of each cable amounting to 0.025 per cent of the cable length in spans A, B and C and 0.055 per cent in span D. Spans A, B, and C, which were stressed to about 8,500 lb., continued to stretch for 30 days and then stopped while span D, which was stressed to about 11,000 lb., continued to stretch for 68 days and then stopped stretching.

From these results it was determined to use 7,750,000 lb. per sq. in. as the modulus of elasticity for the cable when it is first pulled up and 9,800,000 lb. per sq.in. after the cable had taken its permanent set under line loading conditions. The amount of permanent increase in length, under given temperature and tension conditions, which will take place under line loading conditions, was chosen as 0.04 per cent. The total stretch that took place in span D was not chosen because it was believed that very high stress had been maintained on span D for a longer total period than would obtain on a transmission line throughout its life.

Before this information was available line towers had been located on the profile by the use of a template based on a modulus of elasticity of 11,400,000 lb. per sq. in., making no allowance for the permanent stretch of the cable. For this reason it was necessary to accept the sags and clearances to ground at 130 deg. F. as given by the template. To determine the tension to which the conductor should be strung at a given temperature it was necessary to begin with the 130-deg. sag as given by the template, working back to the conductor length at 12,000 lb. under the worst assumed conditions of temperature and loading and using the permanent modulus of elasticity of 9,800,000 lb. per sq. in.; then decrease this stressed length by 0.04 per cent to obtain a temporary maximum tension at the same loading and assuming no further stretch due to this decrease in length; then from this temporary maximum tension and the temporary modulus of elasticity of 7,750,000 lb. per sq. in. the stringing tension at the given stringing temperature was determined.

5—220-kv. Insulator Studies

The insulator study described in this section was prompted by the necessity of extending the 220-kv. lines of the Southern California Edison Company to a new steam plant to be located at the beach. The problem was to determine the proper type of line insulation and outdoor station insulation for such conditions and the proper method of keeping them clean. The work was performed under the direction of R. J. C. Wood, and will be reported also by the insulator research subcommittee of N.E.L.A., of which he is the chairman.

Tests were made on insulator posts made up of heavy 66-kv. pin-type insulators to determine: first, what arrangement of sprinklers and type of nozzle would most effectively clean the insulators; and, second, what were the voltage limitations within which it would be safe to clean badly coated insulators with a spray of water while the bus is energized.

The nozzle finally adopted consists of a 2-hole cupped disc back of which is a 4-hole baffle plate. Edges of the holes in this plate are shaped to give the water a whirling motion in the nozzle. Two nozzles were used, located on opposite sides of the post at a distance of 10 ft. from its center line and 18 in. above the level of its base. Good results were obtained by the use of from 2 to 4 gal. per min. per nozzle.

A 6-unit post with the insulators clean and dry and with a 30-in. diameter circular plate at the top to serve a voltage-grading shield, flashed over at 723 kv. When the clean post was tested with the sprinkler in operation it flashed over at 421 kv. Overall arcing distance was 87 in.

To simulate the unfavorable operating conditions existing at the beach the insulators were sprayed with ocean water and then dusted over with beach sand. Eighteen hours or more later the insulators were tested by applying a given voltage and then turning on the sprinklers. By a series of such tests the critical voltage at which arc-over would occur upon turning on the sprinklers was found to be between 325 and 350 kv. Below this voltage the initial surface discharge would subside to a more or less steady state as the washing continued. Visual observation indicated that a half-hour's washing should be sufficient. Similar tests of a 5-unit post demonstrated that arc-over would occur with 290 kv. applied, and would not occur at 270 kv. These values check those obtained with the 6-unit post in proportion to the number of units.

These tests show that a voltage surge sufficient to cause arc-over must amount to 250 per cent of normal if it occurs at the same instant that the water is turned onto very dirty insulators or 330 per cent of normal if the sprinklers are operating on clean insulators. In spite of this, however, probably it is best to spray the insulators when de-energized and thus avoid the very remote possibility of an arc-over that might be caused by spraying while energized.

To acquire some experience with insulators under actual beach weather conditions 13 strings of suspension insulators of various types of units and of various lengths, and three posts of various lengths have been installed at the Redondo steam plant and energized at approximately 150 kv., line to ground. These insulators have been in position during periods varying from three to six months without being cleaned. They have been energized for approximately one month during which time there have been two rain storms. None of the insualtors has flashed over with the exception of one string of 13 10-in. units which flashed over during a heavy fog after being up without cleaning for a period of six months.

These insulators are energized from a 4,500-kva. transformer connected to the 15-kv. bus of the Redondo steam plant through step-down and step-up transformers, each of 150-kva. capacity, which limit the amount of current which can flow if the insulators should flash over. The switch to the 15-kv. bus is automatic. In series with each string of insulators is a small fuse which will blow and thus give a record of which string has flashed over.

6—Operating Experience

Operating records of the 220-kv. lines in general are better than for lines of lower voltage. Interruptions to the circuits or parts of circuits are due almost entirely to insulator flash-overs caused by birds. This is the experience of both the Pacific Coast systems that have had 220-kv. lines in operation for some time.

Some mechanical troubles due to conductor vibration have been encountered, but all are being overcome by stopping the vibration. This class of trouble is due entirely to physical characteristics and is not influenced by the voltage of transmission.

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Overhead Construction Practice Revision and Joint Pole Practice*

The primary function of this committee is to give constructive criticism and to place before all utilities the changes contemplated in overhead construction rules provided for in the revision of General Order 64 of the Railroad Commission of the State of California. It is intended as a continuation of the work carried on last year by a similar committee of this association. This revision was discussed at the April meeting of the Engineering Section at Fresno. Joint-pole work is an added responsibility of this committee, as it is considered to be closely associated with the requirements for strength and clearance in overhead line construction. Joint-pole work has a background of 20 years' development in California and it is the purpose of this committee to co-ordinate methods and practices with a view to simplification and standardization.

* **Report of sub-committee.—J. E. Macdonald, chairman.** J. Adams, W. B. Allett, V. D. Armstrong, K. B. Ayres, H. L. Caldwell, H. M. Clark, D. I. Cone, R. S. Daniels, F. E. Dellinger, E. Erwin, E. C. Fisher, P. J. Freygang, R. E. Hill, C. E. Larrabee, E. S. Moreland, G. E. Nott, A. C. Putnam, T. W. Snell, W. R. Van Bokkelen, C. W. Walker.

Pole Committees, Associations and Agreements

The California method in joint-pole work is to operate through committees or associations representing the various utilities with a personnel consisting of the distribution engineers, plant superintendents and other representatives who have in charge outside plant construction, operation and maintenance. Such organizations are guided by general contracts which cover the ways and means devised to enter into joint use, to continue in joint use and to withdraw from joint use under the various conditions which arise. These contracts are general in character and do not attempt to set forth positively all the details covering joint use, but rather provide a method whereby joint use may be initiated and completed when the conditions are favorable thereto.

The agreements set forth the scope and purpose of joint use and suggest ways, means, rules and regulations whereby any two or more utilities may enter into and continue in joint use. They specify the territory in which the agreement is operative, the space and position to be occupied by each utility. They provide for an equitable division of expense and costs covering various transactions, fix pole prices and salvage. They include regulations dealing with maintenace, repairs, moving, removing or replacement of poles and equipment; also regulations covering shares for various classes of construction and rules governing guy wires, clearance, crossarms and billing methods. Also they specify the method of identification of joint poles and include a general specification which conforms to legal requirements.

Operating Method

The committee or association acts as an independent organization subject to the direction of the management of the various utilities. This work is in charge of a secretary whose function is to supervise the joint pole work and see that the principles and practices as set forth in the agreements are carried out to their full intent. This is a very flexible method and is adequate to meet whatever conditions may arise, without the necessity of special agreements covering special transactions.

General Activities

The committee, therefore, is particularly interested in the development of joint use under existing agreements and its purpose is to discuss certain principles and practices as defined therein, to promote better inter-utility and public relations, to reduce recording expense to a minimum and otherwise to reduce to a minimum the effort necessary for this activity. The committee is devoting special attention to the development of better co-ordination of method.

The following subjects are being given special consideration:

1. Division of costs for conflicting utilities.
2. Co-ordination of conflicting overhead systems and joint planning.
3. High-tension joint use between supply and communication utilities.
4. Locating poles to avoid public and private improvements.
5. Providing safe clearance for service wires crossing highways.
6. Protecting poles from traffic accidents.
7. Providing space for overhead lines of industrial concerns and privately owned lines not for public service.
8. Costs, depreciation and salvage.
9. Full-length treated poles and joint use.
10. Identification of poles.
11. Joint pole records and routine.

At the San Francisco meeting a number of short papers were presented setting forth the views of various members of this committee upon subjects which previously had been assigned. A remarkable unanimity of opinion was shown as to the methods which have been devised to cover the various situations.

As to the division of costs, it has been conceded that a utility occupying a given location has a prior, but not an exclusive right to such location; an incoming utility is obligated to consider ways and means whereby those prior rights may be maintained with equity to both parties. The first party is entitled to the full capital value of its plant, but must not expect to increase it at the expense of the incoming party. Various ways are being suggested to take care of this situation. In isolated cases involving one or more poles this may be taken care of by arbitrary rules based upon life of the existing pole or poles. Each transaction is subject to field agreements, a very important phase of joint-pole planning and construction.

Supplementing this, and of almost equal importance is the co-ordination of conflicting overhead systems in joint planning. Proper methods of planning reduce conflicts to a minimum and give all parties an opportunity to participate in new construction or reconstruction, if desired. This committee is endeavoring to introduce standard practices covering planning.

Whereas high-tension joint use between supply and communication utilities is a very important subject, yet it may be passed over rapidly inasmuch as each utility must be the sole judge of its service and construction requirements. As such this must remain a problem defined and limited solely by the best engineering solution for each specific case. It is gratifying to note that there is an increasing amount of such joint use and power and communication utilities are agreeing upon the grade of construction and the safeguards to be thrown around the overhead facilities to make such joint use reasonably safe and serviceable.

Development of our highway systems, due to the rapid increase of automobile traffic presents another problem of high maintenance charges due to the necessity for moving pole lines out of the way of public improvements such as street widening and opening. Tree conditions are becoming more unfavorable to pole-line maintenance. It has become more and more necessary to promote and maintain cordial relations with the public and every effort is being made to locate poles so as to eliminate all possible objections to their maintenance.

To obtain proper clearance for service drops over streets, highways, roads, etc., it is desirable by co-operation to interfere as little as possible with other utilities and the public. These wires must be high enough to avoid the various vehicles which have occasion to use the highways. It should be the purpose of the utilities to establish a high standard for maintenance of overhead service wires and a reasonable restriction which should be placed against extraordinary uses of the highways. Between utilities, the mutual use of poles located on opposite sides of the street is being encouraged. Such service wire attachments are made without charge.

The necessity for protecting poles from traffic accidents is another incident of the development of automobile traffic. Permits are being granted by the Highway Commission now only under the condition that the butts of poles shall be painted white to increase visibility. This is an expensive method, particularly so where full length treated poles are involved, as they do not take paint of any kind readily. An alternate proposal has been made to the Highway Commission to substitute white strips of wood placed on the pole on the side toward approaching traffic.

All utilities are called upon at times to provide space for overhead lines of industrial concerns and for privately owned lines not for public service. As far as the utilities are concerned, this is a loss-making activity because of the nominal charges which are made for such contacts, but it is neither desirable nor possible in the interest of public welfare to refuse to permit such attachments if the space is available. The utilities, therefore, are renting contact space for such lines and the effort of this committee is to standardize methods of making and charges to be made for such service.

Pole costs, depreciation and salvage always have been fixed by taking the average values over an extended period. Under development at this time is a method whereby all maintenance charges may be covered by fixed costs, thus obviating the necessity of keeping cost accounting in outside plant operations. This will reduce accounting and other details to a minimum.

Full-length treated poles have been adopted by a number of utilities during the past two years and are being made to fit into the program of joint use. An effort is being made to determine the merits of such poles. Identification of poles is a very important consideration and a standardization of method is desirable. The practice of many companies is to number poles consecutively with appropriate distinguishing mark or initial. This makes the pole a distinct unit in a manner similar to any other piece of electrical equipment which must have identification for record purposes. An effort is being made to standardize in order to make recording more effective.

The purchase and sale price of any joint pole depends entirely upon the length and species of the pole, the year set, and its condition as to painting, stepping, treating, etc. It is desirable that this data be absolutely correct and, when coupled with the pole number and its location, should make a perfect record lending itself to prompt, efficient recording and correct accounting.

Joint use usually is initiated through authorizations which are subject to field agreements thus placing the responsibility for planning strictly in the hands of those utilities, and their employees, which are responsible for the overhead construction. The effort of this committee is to develop this practice so that transactions may be handled as efficiently and effectively as operations under the sole management of one utility.

This is a full program and the response which has been given to the various proposals has been most gratifying. It is believed that when a final report of this committee is made there shall have been prsented a Joint Pole Code of principles and practices that will prove valuable to all utilities.

Grounding of Distribution Circuits*

The sub-committee on the grounding and distribution circuits has considered primarily a subdivision of the general subject, that so far has not been touched by any previous P.C.E.A. committee. At first glance the subject might appear to offer only two methods of approach, namely, the grounding of secondary circuits and the grounding of primary circuits. The first of these has received a great deal of attention by previous committees and has been covered by various reports. The second method has been considered generally only from the substation angle, that is, the grounding of the primary neutral at the substation. Its broader aspect, grounding out on the circuit, was touched upon in last year's report.

It is proposed in this report to consider more thoroughly not only the grounding of primary circuits along the line, but also a combination of both methods of grounding, that is, the common ground or the common grounded neutral for primary and secondary circuits. It will be seen that common grounding will reduce costs, that it is desirable from every angle, and that it tends toward greater safety in operation. As a matter of fact, actual installations of both methods of grounding are general in this state and common grounding has been introduced and proved satisfactory in other states. It is only because we are occasionally conservative in California, and are willing to permit others to try out new and desirable methods before we put them into effect ourselves, that installations of common grounding have not been made heretofore in this state.

To secure an expression of opinion from the various power companies of the state a questionnaire was sent to the members of this sub-committee. This questionnaire covered the major items involved in a consideration of this subject. The facts contained in this report were contained in the replies to the questionnaire, which for the most part were quite complete. The first two methods of grounding will be considered first even at the risk of repeating matter which already has been presented on the subject. To make a complete study of this subject all its various angles must be viewed.

Secondary Grounding

Grounding of secondary distribution circuits has been accepted for a long time by all those concerned with such matters as necessary to provide safe operation. This grounding is provided in either or both of two ways: grounding the secondary neutral at the transformer (and elsewhere) by means of a local ground at that point, and grounding at the house service or services. Methods of grounding depend upon local ordinances and their enforcement. Generally a water-pipe ground is used. In many localities the secondary neutral wire is continuous over a large area, grounded at transformers and elsewhere, the latter being the case where transformers have been moved or removed and the ground connection left. This produces in effect a large overhead ground network. So far as is known this method has proved effective in practice. A ground system of this kind naturally is not intended to carry current to or from the ground. On the other hand it is true that when the network or the grounded neutral is functioning as a protective system it is carrying current until the trouble is cleared.

* **Report of sub-committee.—H. H. Buell, chairman.** D. I. Anzini, V. D. Armstrong, E. R. Banks, R. R. Cowles, O. R. Evans, F. E. Dellinger, J. F. Hodges, H. S. Lane, G. A. MacDonald, E. S. Moreland, A. C. Putnam, G. A. Riley, O. G. Steele, J. O. Tobey.

Primary Grounding

Grounding of the primary neutral naturally presents a similar problem and one which is capable of the same satisfactory solution. In the past practically all urban distribution was handled at 2.3 kv. As loads increased, the simplest method of increasing capacity was that of changing the delta system to star and carrying the neutral conductor throughout the primary network or at least over a large part of it. The advantages or disadvantages of the delta versus the star systems will not be discussed at this time. In order properly and safely to operate the star system the neutral necessarily was grounded at the substation in all cases.

The question at issue in this case is that of the position of the ground or grounds on the primary system. In times past, when the 4-wire primary system first was introduced, it was the practice to ground the neutral of the primary system only at the substation or substations. In this connection it might be mentioned, however, that even in these original installations conditions were introduced which simulated closely the later development, that of multiple grounds on the 4-wire circuits distributed over the network. For instance, it is not at all uncommon for two or more substations to feed into a large 4-wire primary network and, although the phase wires are separated or may be separated, the neutral wires always are interconnected. In the same way overhead circuits dip underground and serve large areas of underground construction. It always has been the universal custom in such installations to ground the primary neutral in every manhole.

No electrical construction is 100 per cent perfect. In spite of every precaution, primary circuits or individual primary wires will come down. This is true especially where pole lines are exposed to auto traffic along the highways. It is natural that every expedient be employed to clear such accidentally affected circuits immediately. With this end in view, a number of power companies over the state have grounded the neutrals of all 4-wire primary circuits at certain definite intervals along the lines and have been so operating for some time.

It is agreed that the breaking of a neutral wire out on the line introduces a very serious hazard in that there will be no indication of trouble at the substation. The circuit will not trip out and the fallen wire may produce a voltage to ground equal to that of the phase wires. The only real solution to this difficulty is the grounding of the neutral at definite intervals out on the circuit to reduce the neutral-to-ground potential at all points. Similarly, the falling of a phase wire, in many cases where the neutral is ungrounded, may not indicate an abnormal condition at the substation nor trip the breaker, but the hazard of high voltage is present. Grounding the neutral along the line has the effect of grounding the fallen phase wire and either tripping the breaker at the substation or indicating an unbalance at that point. In this connection attention is called again to the grounding of circuits in this manner in underground areas, common practice ever since underground distribution first was installed.

Grounds of this type, as opposed to secondary grounds, may carry current under normal conditions and for this reason there are certain fundamental principles which require attention in laying out this type of system and which conform with best practice. In the first place, it is important that the neutral conductor be of adequate size. It is common practice to install neutral conductors of about 60 per cent of the size of the phase conductors. In this way a short circuit out on the line will not be limited by the neutral conductor or ground resistance. It is understood that the neutral conductor will carry a minimum of current normally and the conductor size is not required for normal operating current. In order to achieve this result, it is the practice to balance transformers continuously on a circuit. That is, the balancing current will travel the shortest possible distance in the neutral. Open star banks are reduced to a minimum because of the out-of-phase character of the neutral current in such a bank. The neutral point of 3-phase star banks is kept isolated from the neutral conductor in order to prevent the possible flow of current at the higher harmonics.

As mentioned above, it is the practice, in all cases where the neutral is grounded at regular intervals along the circuit, to carry out these well defined engineering principles. Such installations therefore have been thoroughly satisfactory from every standpoint. In passing it might be mentioned that measurements which were made on a rather extensive 4-kv. network involving up to 10 circuits with a load of approximately 8,000 kw., all emanating from one substation where the neutral was grounded only at the substation, indicated a total neutral current on all circuits together of about 50 amp. If it had been possible to measure the current at the transformer neutral it probably would have been considerably less than this value. This is an indication of what can be done without particular attention to balancing. With the neutral grounded out on the circuits there is no reason why the total neutral current could not be reduced to a tenth of this value by proper and adequate balancing.

The fact remains that a number of power companies in California are grounding the neutral conductor of 4-wire primary circuits out on the lines with entire success. It should be borne in mind also that these same companies are grounding the secondary neutrals along the lines. One of the most important points to be considered is that of the effectiveness of the ground connections. It might be mentioned that several of the power companies ground the primary neutral directly to water pipes, whereas others rely entirely upon driven-pipe grounds or grounds connected to plates. In any event, undoubtedly it is true that the more grounds installed the more effective the grounding will be. One of the before-mentioned companies grounds the primary neutral to water pipes and the secondary neutral to driven pipes. On the other hand, the house-service neutral, as required by law, is grounded inside to the same water pipe which carries the primary neutral ground.

Common Ground System

What has been said about the separate primary and secondary grounded neutrals applies equally well to the common grounded neutral. Such a system will make for better operation, greater safety, and lower construction costs. The latter point is a very important one, and if lines can be constructed at less cost without sacrificing safety or operation and with even greater safety and better operation, a stride forward will be made. Everyone must agree that construction costs are increasing in spite of standardized methods and it is necessary that any measure which reduces these costs, if there are no objectionable features introduced at the same time, must be most carefully considered and weighed from every angle and adopted if found expedient. The common ground system satisfies these requirements.

It hardly seems necessary to outline the desirable features of such a system from the standpoints of both operation and safety. The discussion already presented and the facts previously enumerated seem to cover the situation. However, a short review of them might be in order. In the first place, a number of power companies already are operating with the neutral of a 4-wire primary circuit grounded at regular intervals along the circuit for very obvious reasons, primarily to provide safer operation of the circuit concerned. This unquestionably is a desirable and necessary arrangement. These same companies and all others are operating with the neutral of all secondaries supplying 110 and 220-volt service grounded either to the same pipe system to which the primary neutral is grounded or to artificial grounds, or both. Naturally the closer together these neutral grounds are placed the smaller the voltage gradient which will exist in any definite distance.

Many companies in the state operate underground systems which employ the common ground for primary and secondary circuits and have operated them satisfactorily for years. In fact, this type of construction is considered ideal. In this case the common ground naturally is grounded at frequent intervals and generally by artificial means. The next step is the installation of overhead primary cables. These have been found economical in many localities and the only construction which could be utilized to serve certain consumers or certain areas. When these cables operate at 4 kv. star the neutral is carried separately and for obvious reasons must be grounded at points other than at the substation. In such cases it is only logical that this primary neutral and the neutral of secondary circuits along the path of the cable be one and the same, for the same reasons as are applicable in underground construction.

One step further takes the primary conductors out of the cable and spreads them over the arm and the same facts warrant and justify, if any justification is necessary, continuing the common neutral throughout the

system. It is evident that if the generally accepted plan of making the neutral conductor approximately 60 per cent of the size of the associated phase wires is followed, the neutral conductor will be amply adequate to carry the necessary secondary balancing current and the small primary balancing current ordinarily found. The primary reason for a conductor of this size is to permit proper breaker operation in case of a short circuit or wire failure. When all neutrals on adjacent circuits in urban areas are tied in together the neutral conductor might be made even smaller than the present accepted size and costs still further reduced, though this is not necessarily recommended at this time. It should be borne in mind that there are several construction economies possible with the common neutral, by reason of one less wire on a pole, but these will not be described in this paper.

Although the common neutral is not employed in California at this time except in underground construction, it has been embodied in distribution construction in a number of localities in other parts of the United States. In spite of the fact that those familiar with its satisfactory operation are enthusiastic about it and California companies could well be guided by that fact in a decision on the subject, it seems desirable to consider the matter from every angle before passing judgment. Probably the most satisfactory method of approach would be the installation of such a system under typical California conditions so that it might be studied and tests made which would prove conclusively its advantages.

Line Protective Equipment and Line Switches*

Under the subject of line switches, there are various types of air break, oil-break and combined air-and-oil-break, and there are many applications to which each is particularly adapted.

In considering the air-break type of switch it is found to be installed principally for the purpose of sectionalizing lines when it becomes necessary or advisable to shift load from one feeder to another, for the separation from their feeders of branches that

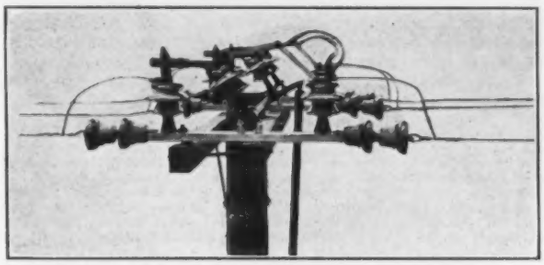

Fig. 1. Sectionalizing air-break switch, closed.

are in trouble or for the killing of sections of loop feeders for purposes of construction or repair. These switches ordinarily are not expected to break heavy loads and usually are operated to interrupt little more than line charging current. Where it is necessary to interrupt load it usually is done with oil circuit breakers although some member companies are installing combined air-and-oil-break switches for this purpose In the air-break switches the vertical type of break has certain advantages over the horizontal break, which advantages have caused them to be adopted for pole mounting almost universally on the Pacific Coast. The horizontal break fills an important place on substation structures where there is more room for mounting, and a double break is advisable.

Air-break switches of the fusible type sometimes are installed on lines branching from feeders, especially where these branches go into river or creek bottoms to serve pumping plants. Where the branch is carried on transmission poles and conditions are such that frequent fuse renewals may be expected it is the practice of some companies to install two switches operated by one handle, with the fuses between the switches. This arrangement allows the replacement of fuses without danger from any induced voltage due to parallel lines.

Accepted practice in pole mounting of air-break switches is to bring the operating rod down the pole,

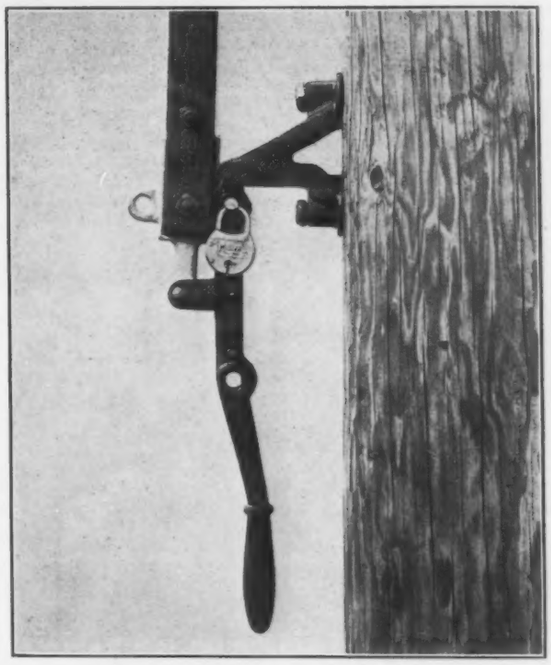

Fig. 2. Lock arrangement on operating rod of air-break switch.

mounting the handle at a point where the switch may be operated from the ground. The advantages of this are that the switch may be operated more easily and more quickly and tearing of the pole with spurs is avoided. As the operating handles can be locked with the switch in either the open or closed position there is slight danger of unauthorized persons tampering with it.

As to the portion of radio interference that does originate on power lines it has been found that air-break switches are among the worst offenders, there being two distinct ways in which they cause this trouble. One cause is poor contact due to burning of the blades and jaws. This may be caused by poor alignment or adjustment; by dirt having collected while the switch was standing open, or by corrosion of the blades while standing open.

Numerous remedies have been tried with varying success. Periodical inspection and readjustment, especially where the line must be de-energized for this pur-

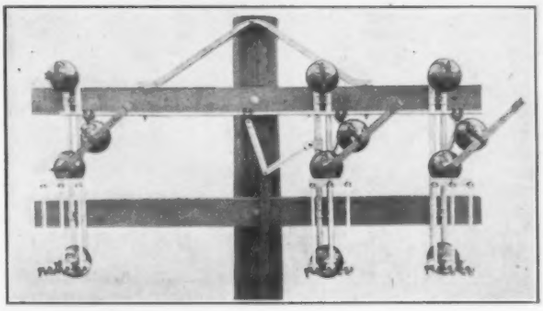

Fig. 3. Multiple-fused switch developed by San Diego Consolidated Gas & Electric Company.

pose, is an expensive operation as also is a periodic cleaning with emery cloth. Numerous greases have been used to prevent corrosion, but have the disadvantage of collecting dust and sand when standing open.

* Report of sub-committee.—K. B. Ayres, chairman. H. L. Caldwell, R. R. Cowles, R. S. Daniels, P. W. Greenleaf, G. H. Hagar, H. F. Hartzell, B. C. Holst, H. H. Minor, E. S. Moreland, R. W. Muller, G. A. Riley, T. W. Snell, E. R. Stauffacher, J. O. Tobey, W. R. Van Bokkelen, W. L. Winter.

What is needed for switch blades and jaws is a non-corrosive conducting metal.

The other and most common cause of radio interference from these switches is the poor electrical contact made in the movable points of the operating mechanism. A condition sometimes exists which causes a static spark to maintain between connected members. This condition usually is overcome by solidly bonding all switch hardware, using flexible bond wires where necessary.

The subject of lightning protection is one upon which little information is available due to the fact that most

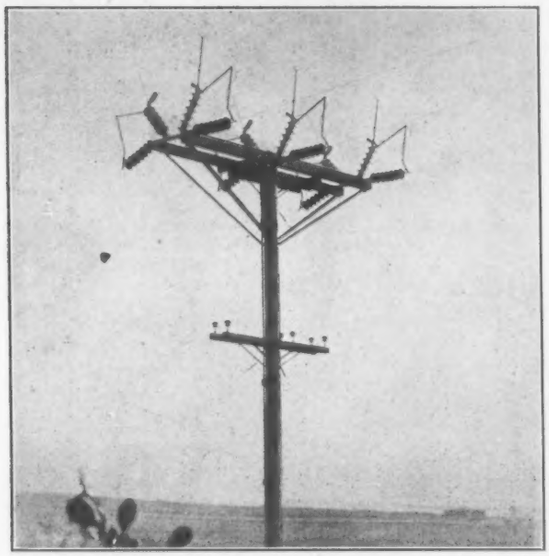

Fig. 4. Vertical high-tension air-break switch.

member companies on the Pacific Coast claim practical immunity from lightning troubles. Some companies, however, claim a high percentage of trouble and property loss traceable to this cause. Those companies operate lines extending well inland and have transmission lines extending into the mountains.

In general the practice regarding lightning seems to be to provide protection at substations and on or near cable-terminal poles. Substation protection is provided by either electrolytic or oxide-film arresters. Other points where protection is provided are equipped with autovalve compression-chamber or the pellet-type arresters.

The problem of fuse standardization was carried over from last year, but for several reasons little progress has been made toward a solution. All manufacturers of high-tension fuse equipment have designed their cut-

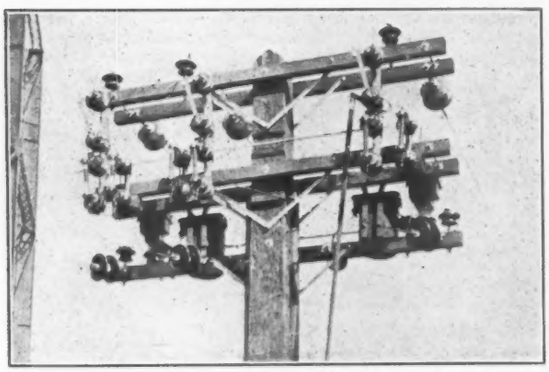

Fig. 5. Combined disconnecting switch and fuse.

outs, fuse tubes and fuses to incorporate special advantageous features which they have covered by patents. This introduces a practically impassable barrier to the standardizing of cutouts, as different manufacturers certainly would not agree to abandon their patent rights.

Fuse tubes used in these cutouts are of various sizes, both as to length and diameter, and in addition have contacts of various spacings and design and are made of different materials. Should an attempt be made to standardize the fuse tubes the majority of manufacturers would have to change the design of their cutouts to accommodate the standard tube. That would mean an enormous expense in time and machinery and in many cases would prohibit the use of special features which have been very carefully worked out.

The standardizing of fuse links would seem to present another line of difficulties, for even if a fuse link were

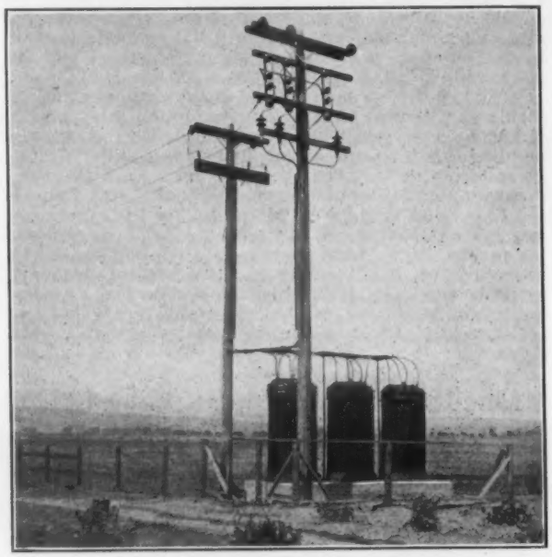

Fig. 6. Typical installation of combined disconnecting switch and fuse.

made with a head that would clamp in all tubes, and be of such a length that by cutting off it could be made to fit all tubes, the characteristics of such a link would be changed materially by the length and internal diamter of the tube.

Last year's sub-committee made a very definite recommendation as follows:

> It would seem advisable for all of the manufacturers to adopt a similar rating. That is, a 100-amp. fuse should carry normally not more than 65 amp. and the fuse should melt in less than 5 min. at a current not exceeding 150 amp. It may be noted that this is a much wider variation than the Board of Fire Underwriters require for link fuses, but owing to the length of the fuse and the amount of heat dissipated, it is inadvisable to rate them as closely as the Fire Underwriters rate link fuses.

A further study of the question of fuse standardization this year has not brought out any information which would tend to modify last year's recommendation.

With such a standardization of fuse ratings it would be necessary of course to use fuses manufactured for the particular cutout and tube in which they are to be placed, as the rating of any fuse would be reliable only when used in the proper cutout.

Life of Threaded and Unthreaded Poles*

Data on Life of Poles

A study was made of condition and estimated life of poles on The Southern Sierras Power Company system by joint inspection of a representative of power company and the Railroad Commission. This study covered territory from east central California (Mono Lake) to the Mexican border and Yuma, Arizona. Practically all are cedar poles, some treated and some untreated. The territory was divided into three districts, northern, central, and southern. A total of 407 poles was examined carefully and complete notes made of condition and estimated life of each. The following pole-life information was determined from this data:

* Reuort of sub-committee.—E. Y. Porter, chairman. R. G. Boyles, H. H. Buell, S. M. Bullis, H. L. Caldwell, J. E. Crilly, R. E. Cunningham, F. E. Dellinger, A. S. Glasgow, G. H. Hagar, H. F. Hartzell, R. W. Muller, J. B. Naugle, H. D. Nesbit, T. W. Snell, J. O. Tobey, W. R. Van Bokkelen, W. W. Wilkinson.

1. Untreated pole to stubbing..... 17 years
   Untreated pole total with one stub.. 27 years
2. Butt treated ("B" treatment) to stubbing ..... 28 years
   Butt treated ("B" treatment) with one stub ..... 35 years

Termites

Data as to distribution of termites was: None found north of Bishop, a very few in the vicinity of Bishop and Keeler, and in increasing numbers south as far as Banning; less numerous in Coachella and Imperial Valleys; most numerous in the central district, in the vicinity of Riverside, Corona, Elsinore, Perris and Hemet.

A pole which seemed to be badly infested with termites was removed, cut and split into sections to show the extent of damage at and above the ground line. The conclusion was reached that action of termites above ground was not sufficient to weaken the pole seriously.

The Railroad Commission also advised that a study of pole life was made for parts of the Pacific Gas and Electric Company system with the following results:

For 40 and 45-ft. treated poles..... 27 years
For 40 and 45-ft. untreated poles..... 19 years

It was noted that the life of longer poles was greater and the life of shorter poles less than these figures.

R. W. Muller of the Pacific Gas and Electric Company at Red Bluff, Calif., reported that 56 full-length retort-treated Douglas fir poles have been set in a 60-kv. line north of Corning. These have been in the ground only one year. Termites have been found to be working in that district, but apparently not to any serious extent.

W. R. Van Bokkelen of the Coast Counties Gas and Electric Company reported upon two lines built in 1913:

1. Line in the vicinity of Hollister, Calif., untreated, practically every pole stubbed.

2. Another line (location not given), brush treated, approximately a dozen poles in 13 miles of line have been stubbed.

This company began using "B" treatment on poles in 1921, but has used no full-length treated poles.

Kurt C. Barth, director of the research division of the Western Red Cedar Association, has made a report of a special investigation which he made during the fall of 1926, covering the entire Pacific Coast. His conclusions are to the general effect that proper butt ("B") treatment of cedar poles preceded by perforations was an effective protection for the large majority of poles and resulted in an average life of from 25 to 30 years.

E. N. Tandberg, plant engineer of the Santa Monica (Calif.) Bay Home Telephone Company, reported 120 poles removed from service of which 40 per cent were "B" treated and all badly infested with termites of both species. The average life of the above lot of poles was 10 years. Another lot of 30 untreated poles in service less than two years was found to be in need of immediate replacement because of termite damage.

Treatments

The following matter pertaining to pole treatment has been submitted to this sub-committee by pole producers:

1. Specification for 8-lb. rueping empty-cell treatment as published by the International Creosoting Company and used generally for treatment of southern pine poles.

2. Specification for retort treatment of Douglas fir poles as recommended by three Pacific Coast creosote treating plants. Also covers physical specifications for poles which will be discussed under heading "Pole Taper and Strength." Specification is supplemented by a diagram of typical treating plant for above process.

3. Special experimental treatment of excessive duration and at high temperatures by R. F. Dreitzler of the Pacific Creosoting Company, December 20, 1926. This test was conducted to determine the maximum temperature which could be safely used in retort treatments. Wet poles boiled 100 hr. in creosote at 230 deg. F. under 24-in. vacuum did not show evidence of overheating, but when same charge was boiled further for 68 hr. at 250 deg. F., the wood fibers were damaged. Another charge of dry poles boiled 96 hr. at 230 deg. F. under 24-in. vacuum showed slight damage. A third charge boiled 120 hr. at 200 deg. F., 24-in. vacuum showed no damage.

4. Mr. Boyles of the Southern California Edison Company sent a report of a special retort treatment of new and old cedar poles, results of a test run on poles furnished by the Southern California Edison Company. Treatment by Pacific Creosoting Company at Seattle. A wide variation of creosote retained by different poles was noted. Mr. Boyles also reported that the cost of treating reclaimed cedar poles averaged $2 each.

5. A paper on the Montan Wax Treatment by J. R. Coolidge was received with a letter from R. E. Meyers, chemist for the International Creosoting and Construction Company of Galveston, Texas, who stated that experiments were in progress, but not far enough along to report results.

6. A letter from R. M. Morris of the American Lumber and Treating Corporation advises that steps are being taken to establish a treating plant on the Pacific Coast for the Wolman Salts treatment.

7. Much interest has been aroused by a new process of pole treatment developed in Los Angeles, in which poles first are treated with paraffin and then by a creosote bath in open or closed tanks. This process will be given further study.

8. The question of conductivity of retort-treated poles has been discussed previously and it has been shown conclusively that conductivity is due solely to moisture in the pole and not to any conducting quality of the creosote.

Pole Strength and Taper

The proposed revision of General Order 64 gives the following values for ultimate fiber stress in poles. From rule 34.21:

Port Orford cedar	6,900 lb. per sq. in.
Douglas fir	5,400 lb. per sq. in.
Western red or white cedar	5,100 lb. per sq. in.
Redwood	3,900 lb. per sq. in.
Pine	6,800 lb. per sq. in.

An extensive series of tests by the U. S. Forest Service in collaboration with the University of Colorado at Boulder, Colo., and the University of Washington at Seattle gave the following results on green or unseasoned timber as follows (seasoned poles approximately 50 per cent stronger):

Wood	Fiber Strength
Southern yellow pine (dense)	7,300 lb.
Douglas fir (dense)	7,300 lb.
Southern yellow pine (sound)	6,300 lb.
Douglas fir (coast)	6,300 lb.
Tamarack	6,000 lb.
Hemlock (western)	5,600 lb.
Cypress (bald)	5,600 lb.
Douglas fir (Rocky Mountain)	5,300 lb.
Chestnut	4,600 lb.
Pine, lodge pole	4,500 lb.
Cedar (western red)	4,300 lb.
Cedar (northern white)	3,400 lb.
Spruce, Engleman	3,400 lb.

The question of strength enters this discussion because of the proposed specification for Douglas fir and southern pine full-length treated poles without minimum limitation as to butt or ground-line diameter. Measurements of some 800 Douglas fir poles made in the yards of the Pacific Creosoting Company at Seattle and the Chas. R. McCormick Company at Portland show an average taper of 0.066 in. per ft. with a minimum of 0.016 in. per ft. The Southern California Edison Company found an average taper of 0.089 on 24 Douglas fir poles, 0.089 on eight southern pine poles and 0.136 on 28 cedar poles, while the Pacific Gas and Electric Company found that cedar poles averaged 0.153 in. per ft. It has been suggested that specifications for Douglas fir or southern pine poles provide that "minimum taper for poles 30 ft. or longer be 0.05 in. per ft. or 20 ft. of length per inch of taper.

The above data on Douglas fir poles as reported from Seattle and Portland was based upon practically "woods run" quality of timber. The data on cedar and southern pine poles was from Southern California Edison Company and Pacific Gas and Electric Company selected yard stocks.

Pole Framing Prior to Full Length Treatment

Blue prints showing recommended or specified framing, gaining and boring for poles which are to be retort treated have been submitted by the following: W. W. Wilkinson for the Texas Creosoting Company, "Black Diamond"; R. G. Boyles for the Southern California Edison Company, 35-ft., 40-ft., 45-ft., 50-ft., 55-ft., 60-ft. poles and up; E. Y. Porter for The Southern Sierras Power Company, Class L and H lines and stubs.

There appears to be such a diversity of requirements that it seems almost impossible to arrive at any uniform system or plan, but the matter should be discussed further and if not possible to arrive at a satisfactory common agreement to definitely drop this matter.

Prime Movers Committee Reports[2]

Steam Plant Operation Data*

Heat Balance

Practically all large turbines recently installed have been equipped for stage bleeding at from two to four stages, air pre-heaters or economizers being added, according to the heat-balance arrangement of the particular station. Usually the closed type of heaters are used actually forming a part of the condensate-return system. They require little or no attention when starting, stopping, or varying load. Where deaerators are used, when operating at extreme low loads, steam from a higher turbine stage or live steam may be required for good deaeration due to reduced stage temperatures and pressures.

Usually two or three stages of bleeding are used where the system includes economizers and three or four stages where air heaters only are used. It is interesting to note a tendency for more plants to use four stages of bleed. Some plants now using one or two points only are providing four for future use. There is little uniformity regarding the points at which various sizes or types of turbines are bled, although the lowest heater usually is placed to raise the feed temperature to 140 deg. or 150 deg. F. corresponding to 3 or 4 lb. abs.

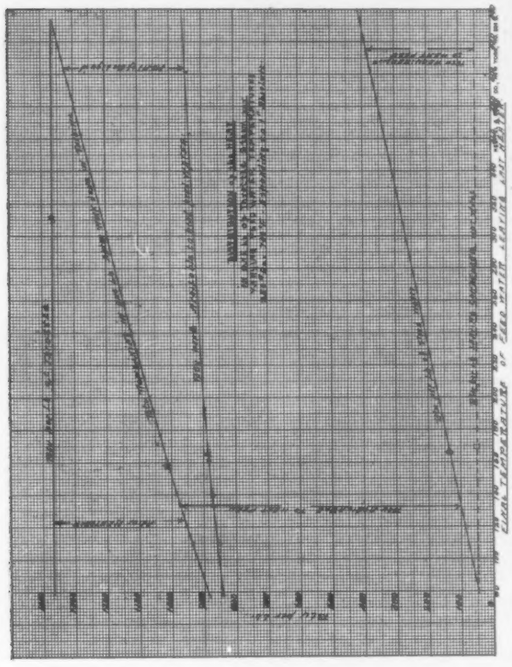

Fig. 1. Distribution of heat in 1 lb. of throttle steam for varying feed-water temperatures; 350 lb., 700 deg. F., expanding to 1 in. absolute.

Final temperatures from the last heater vary from 200 deg. F. at Avon station (with 1-stage bleed and 69 per cent economizer surface without air heaters for a header pressure of 375 lb.) to 362 deg. F. at Seal Beach (with 4-stage bleeding, air heaters without economizers, and steam pressure of 350 lb.). Long Beach, the only other Pacific Coast plant at present using the regenerative cycle, uses three stages of bleeding with a final temperature from the last heater of about 300 deg. F. on two units equipped with 76.3 per cent economizers and no air heaters. A third unit at that plant, with 3-stage bleeding including air heaters, is designed for about 320 deg. F. from the last heater. Economizer surface for this third unit has been reduced to 46.3 per cent. Steam pressures in each case are about 380 lb. at the turbine throttle.

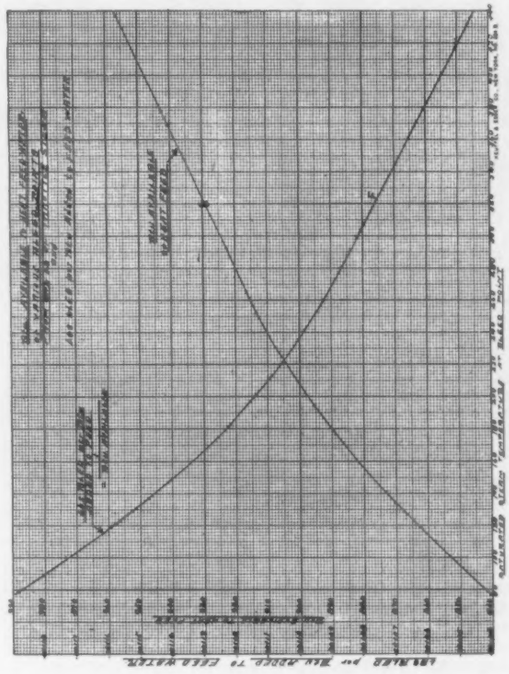

Fig. 2. B.t.u. available to heat feed water at various bleed points from 1 lb. of throttle steam, and, lb. per B.t.u. added to feed water.

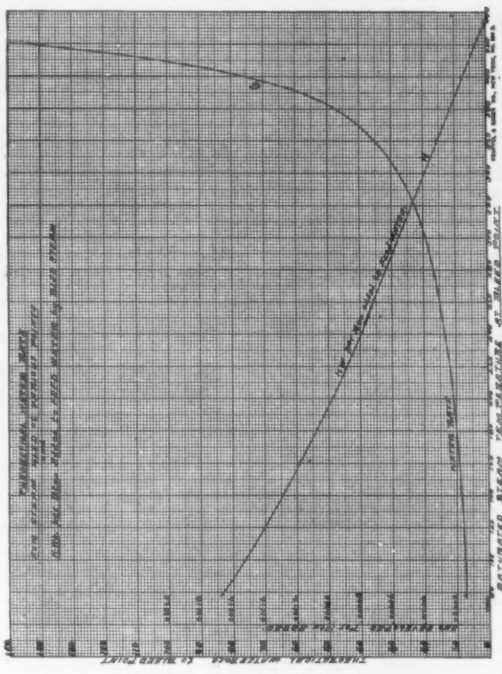

Fig. 3. Theoretical water rate for steam bled at various points, and, kw-hr. per B.t.u. added to feed water by bled steam.

[2] **C. W. Wiggins,** San Diego Consolidated Gas & Electric Company, chairman. **F. G. Philo,** Southern California Edison Company, vice-chairman. **General Electric Company:** H. E. Fuqua, R. F. Monges. **Great Western Power Company:** H. S. Markey. **Hunt-Mirk Company:** P. M. Robinson. **Los Angeles Gas & Electric Corporation:** F. R. Knight, R. F. Leefeld, E. G. MacDonald, W. Reed, C. H. Zeise. **Pacific Gas and Electric Company:** L. D. Burlingame, C. C. Chapman, C. H. Delaney, F. P. Ellis, V. F. Estcourt, R. C. Powell, C. E. Steinbeck, J. H. Stott. **San Diego Consolidated Gas & Electric Company:** E. D. Sherwin. **San Joaquin Light & Power Corporation:** A. Y. Meudell. **Southern California Edison Company:** J. W. Andree, H. O. Bennett, Scott Jensen, L. J. Kraps, W. H. Short, W. E. Thompson, R. D. Wallingford, R. Wilcox, H. T. Woodworth. **The Southern Sierras Power Company:** V. E. Johnson. **Western States Gas & Electric Company:** M. C. Wheyland.

* **Report of sub-committee on heat balance and station auxiliaries.—F. G. Philo, chairman.** L. J. Kraps, R. F. Monges, R. C. Powell, W. Reed.

In a contemplated addition to the Long Beach plant it is proposed to omit the economizers entirely and heat the feed to a final temperature of 385 deg. F. by 4-stage bleeding, the last heater taking steam from the fifth stage at about 222 lb. abs. Larger air heaters are included with the boilers. In any installation it is to be

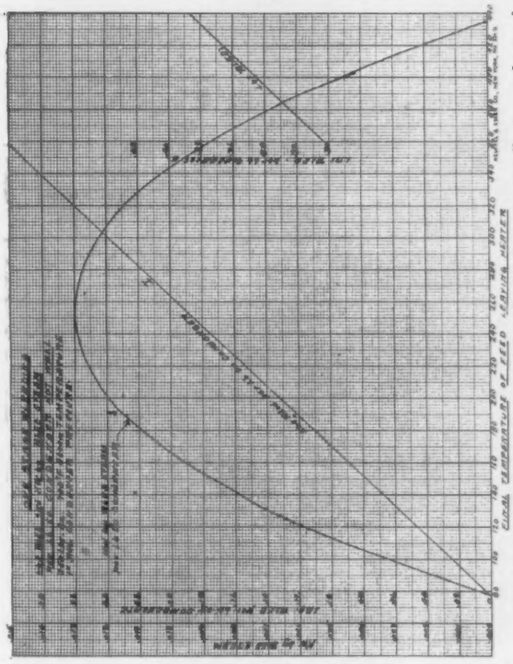

Fig. 4. One-stage bleeding; lb. bled and kw. by bled steam per lb. to condenser hot well; 350 lb., 700 deg. F., to 1 in abs. condenser pressure.

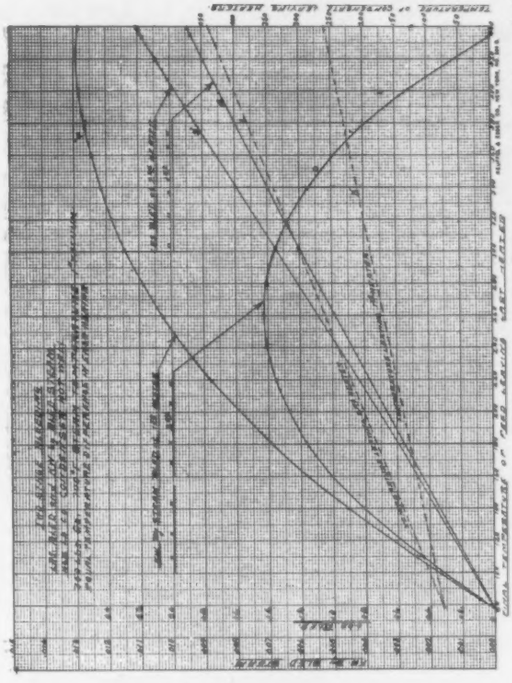

Fig. 5. Two-stage bleeding, lb. bled and kw. by bled steam per lb. to condenser hot well; 350 lb., 700 deg. F., 1-in. vacuum, equal temp. range in each heater.

understood that the temperatures in the bleeder heaters vary with load and to some extent with the vacuum.

Without attempting a discussion of the many possible arrangements of heaters the studies presented herewith in graphic form have been prepared to show the economy to be expected by various heat-balance systems. Steam conditions in each case are 350 lb. gage, 700 deg. F., and 1-in. abs. pressure in the condenser. Theoretical values for expansion in a perfect turbine are considered. In each case the curves cover a range of final feed temperatures leaving the last heater varying from condenser temperatures, or a condition where there is no heating of the feed water, to a temperature corresponding to saturated steam at throttle pressure, which is equivalent to heating with live steam in the last heater at throttle pressure.

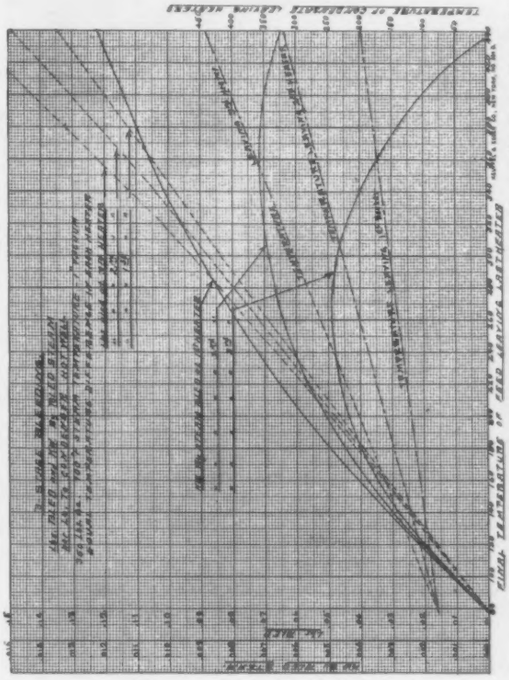

Fig. 6. Three-stage bleeding, lb. bled and kw. by bled steam per lb. to condenser hot well; 350 lb., 700 deg. F., 1-in. vacuum, equal temp. range in each heater.

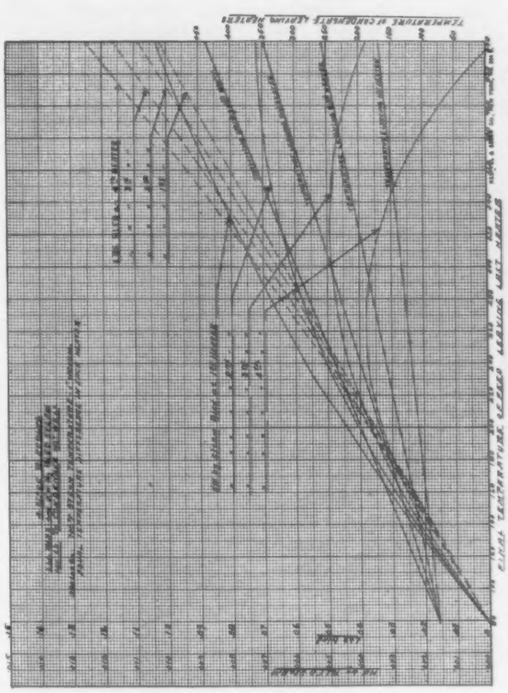

Fig. 7. Four-stage bleeding, lb. bled and kw. by bled steam per lb. to condenser hot well; 350 lb., 700 deg. F., 1-in. vacuum, equal temp. range in each heater.

Final temperatures are plotted as abcissae in each case, instead of bleed pressure, in order to keep the curves more open at the low range where the temperature changes are great for a small variation in pressure.

Figure 1 shows the relations between the various steam and water conditions assumed. Curves A and C are respectively the heat content of the throttle steam and the condensate leaving the hot-well and are con-

stant values for the assumed conditions. Curve B is the heat remaining after work done in the turbine. The work done is represented by (A — B) which approaches zero as the point of bleed is moved toward the throttle.

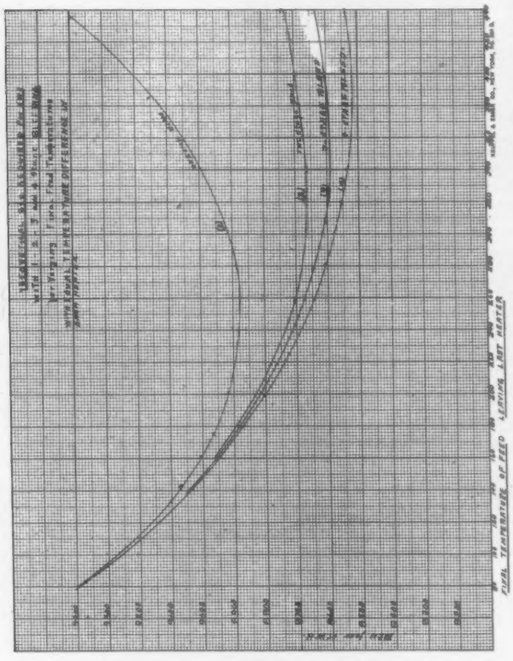

Fig. 8. Theoretical B.t.u. required per kw-hr. with 1, 2, 3 and 4-stage bleeding; various final feed-water temperatures; equal temp. range in each heater.

D is the heat content of the feed from the last heater (B — D)=E, the B.t.u. per lb. available to heat the feed water to the given temperature, while (D — C) is the B.t.u. required per lb. on the unit capacity of the feed water to absorb heat from bled steam. Curve E from Fig. 1 is shown on a larger scale in Fig. 2, to which has been added curve F, showing the pounds bled per B.t.u. added to the feed water. This is the reciprocal of curve E.

The theoretical water rate at any turbine stage is equal to 3,415 divided by the adiabatic heat drop to that stage, or, it equals 3,415 divided by values of curve (A — B) from Fig. 1. These values are shown in curve G in Fig. 3. If the pounds bled per B.t.u. added (curve F, Fig. 2) is divided by the theoretical water rate (curve G, Fig. 3), the results will be the kw. developed by bled steam per B.t.u. added to the feed water as shown in curve H, Fig. 3.

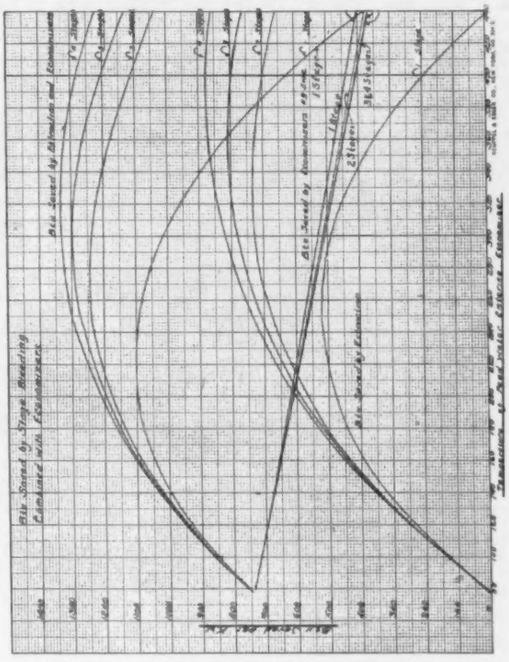

Fig. 10. B.t.u. saved by use of stage bleeding combined with economizers.

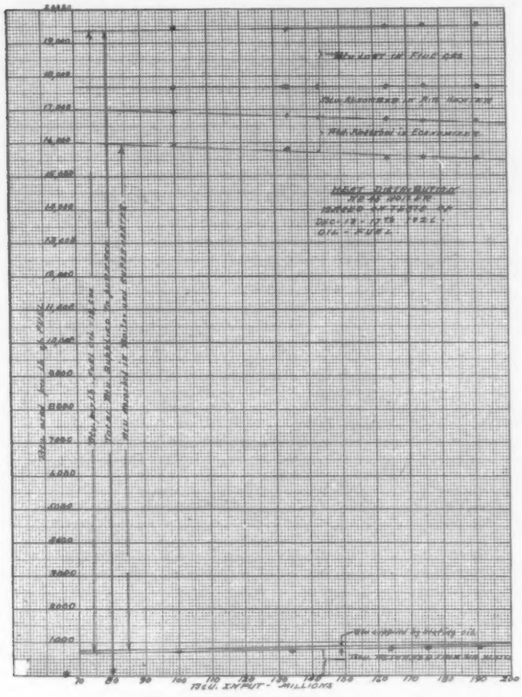

Fig. 9. Heat distribution of a certain boiler.

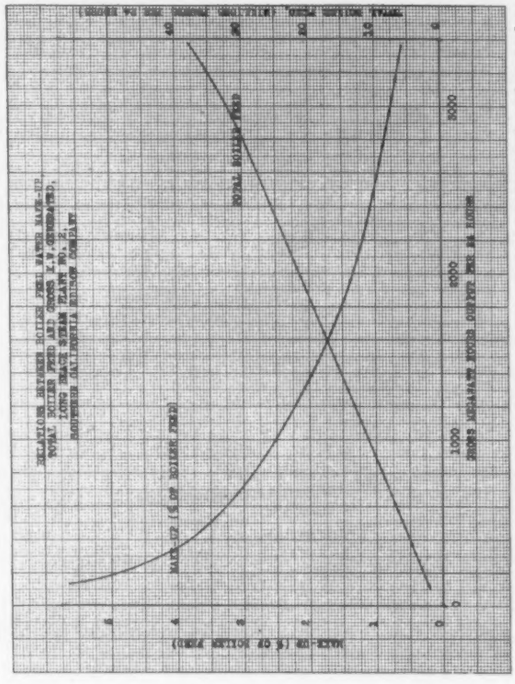

Fig. 11. Relation between boiler feed-water make-up, total boiler feed, and gross kw. generated, Southern California Edison Company, Long Beach No. 2.

From these three curve sheets the heater performance at any stage may be calculated. Knowing the B.t.u. per pound to be added to the condenser, the pounds bled at any point are secured by multiplying by values

from curve F; and the kw. developed by bled steam equals the B.t.u. added multiplied by values from curve H. Total pounds to the throttle per pound to the condenser equal 1 + lb. bled, and the total kw. developed equals kw. developed by bled steam plus kw. by 1 lb. to the condenser. For any final temperature of feed the B.t.u. per kw. equals (H—h) multiplied by the pounds to the throttle divided by the total kw. developed.

Figure 4 shows characteristic curves obtained by one stage of bleed. Curve I pounds bled per pound to condenser is practically a straight-line function of the temperature of the feed water leaving the heater. Curve J (kw. by bled steam) reaches a maximum at about 250 deg. F. corresponding to 30 lb. abs. Since the B.t.u. required per kw. are least when the kw. by bled steam is greatest this corresponds to the most efficient point for the combination. When the temperature leaving the heater reaches 435.9 deg. F., corresponding to saturated steam at throttle pressure, the condition then is one of heating with live steam.

Figure 5 is a corresponding characteristic for two bleed points, assuming an equal temperature rise in each heater. Curves K and L are respectively temperatures leaving the first and second heater; curves M and N are the pounds bled per pound to the condenser and curves O and P are the kw. developed by steam bled to each heater. The combined economy in B.t.u. per kw. are shown on curve 2, Fig. 8.

Figures 6 and 7 are corresponding characteristics for three and four bleed points. The final results of the combination in each case are shown on Fig 8, curves 3 and 4.

Figure 9 shows the heat distribution in a 1,500 hp. boiler equipped with 46.3 per cent economizers and air heaters, using oil fuel with 13 per cent excess air to the furnace. These are observed results and allow for air leakage in the settings.

Figure 10 shows the saving in B.t.u. per kw. secured by one, two, three and four stages of bleed, together with the savings secured from the above economizer installation in each case. It is assumed that the boiler operates at a constant rating of 280 per cent and that combustion conditions remain constant. The upper set of curves in Fig. 10 shows the combined economy for stage bleed and economizer in each case.

It is interesting to note that the addition of economizers has a tendency to shift the economical point of bleed toward the exhaust-end of the turbine, depending upon the characteristics of the economizer.

Measurement of Fuel Oil

The usual method of measuring oil is to gage the depth of oil in the tank at start and finish, using a tape or rod and taking temperatures at one or more points in each case, correcting to a standard volume at 60 deg. F. An alternative method would be to gage the tank at start and finish, reading the temperature of the incoming oil. The volume received would be equal to the differences in volumes indicated by the two gages corrected for the temperature of the entering oil. This could be expressed by the formula:

$$V_d D_d = (V_b - V_s) D_d$$

where V and D are the volume and density respectively and the subscripts d, b and a identify respectively delivered oil, oil in the tank at start, and oil in the tank at the finish. See Fig. 11.

This formula will be correct, assuming that the specific heat of the oil is constant and that the density of the oil varies inversely as the temperature; that is, assuming $D=\frac{K}{t}$

Equating the heats in the oil volumes:

$$W_d C t_d = (W_b C t_b) - (W_s C t_s)$$

where C is the coefficient of expansion and td, tb and ta respectively are temperatures of delivered oil, and of oil in the tank at start and at finish of the run. Substituting volume multiplied by density for the weight, this becomes:

$$V_d D_d C t_d = (V_b D_b C t_b) - (V_s D_s C t_s) \text{ or, since } D=\frac{K}{t},$$

$$V_d K = (V_b K) - (V_s K) \text{ or, } V_d = V_b - V_s$$

The value of this method depends upon the ability to get an average value of the temperature of the incoming oil. Where oil is supplied through a pipe line, at the start of the run the oil will be cold and the rate of flow will be low. After the line becomes warm the rate of flow will increase. This could be allowed for by repeated gagings of the tank, and weighting the temperatures according to the rate of flow.

The chief objection to measuring the oil by the old method is in the difficulty of getting a temperature reading that is an average figure for all parts of the tank. This problem is simpler than it would seem at first, however. Consider a tank of oil having a series of different average temperatures measured in vertical lines. Since the pressure at the bottom of a level tank is equal at all points, the weights of oil in vertical columns must be the same. This gives a wavy surface to the body of oil. If the temperature along a vertical line at a point where a wave contour is co-incident with the normal level surface is taken as standard the depths at all other points corrected to temperature would give an equivalent surface represented by the normal level oil surface. It is apparent that unless the oil is excessively viscous this condition will not exist. The oil in the higher waves will flow into the hollows increasing the pressure below and causing the heavy oil to flow under the lighter as shown by the arrows. This will reach a state of equilibrium where the oil lies in horizontal plane layers, the densest at the bottom and the lightest at the top. It is apparent that the average density, and therefore the average temperature along any vertical line is the same at any point in the tank. The problem of measuring the average temperature of the oil in a tank, therefore, is one of getting a true average along any vertical line.

Operation and Maintenance of Condensing Equipment*

This committee has tried to analyze the problems of condenser operation, particularly those over which the operator has control to a certain extent such as operation of circulating pumps, cleaning of tubes and prevention and location of air and tube leaks. In one instance standards of operating costs have been established and the actual cost compared to the standard.

Statement from San Diego Consolidated Gas & Electric Company

This company reports that it has one fairly efficient turbo-generator provided with a condenser which is not split, and one circulating pump. Tube leaks necessitate the capping of about 20 tubes per week and the condenser therefore is opened up at least once a week, sometimes oftener.

The unit in question is a 15,000-kw. unit with a 28,000-sq. ft. Worthington condenser, horizontal, 2-pass, 5,348 1 x 242¾-in. tubes, No. 18 B.W.G., admiralty brass. Circulating water is supplied by a steam-and-motor-driven 30-in. circulating pump of 30,000 gal.-per-min. capacity.

Two cleaning methods are used: air and water. The tubes are cleaned with a water lance twice a week while the condenser is in operation. The nozzle is ¼ in. and sea water is used at 225-lb. pressure. Tubes are cleaned with air once a week when the condenser is down for locating leaks, a ½-in. nozzle is used with 100-lb. air pressure. The cleaning with water lance requires four hours or 2.7 sec. per tube, one man to do the work, and costs as follows:

Labor	$2.90
Material	0.25
Drop in vacuum	0.00
Total	$3.15

The cleaning with air requires two hours or 1.35 sec. per tube, three men to do the work, and costs as follows:

Labor	$9.00
Material	0.40
Drop in vacuum	49.70
Total	$59.10

* Report of sub-committee.—Scott Jensen, chairman. R. F. Leefeld, P. M. Robinson, J. H. Stott.

The principal item, drop in vacuum, covers the loss caused by operation of other units while this unit is shut down. A gain of from 0 to 0.2 in. in vacuum is obtained after air cleaning. The gain after water cleaning varies from 0 to 0.1 in.

Leaks are determined by a recording salinometer and are located by filling the steam side with water. The annual cost of locating and repairing leaks runs between $6,000 and $7,000 and the cost due to impurities in the condensate from condenser leaks averages $3,000 per year.

Tube leakage is believed to be caused principally by air in the condensate. It has been retarded to some extent by painting the inlet ends of the tube insides with P. & B. paint or Duco. This is effective for two or three months, but is expensive, as a treatment costs $185. Cast-iron stars have been screwed into the tube sheet with good results. At present the company is working upon a balanced negative-return system in conjunction with the electric railway and telephone companies. This, when complete, should reduce any deterioration due to electrolysis.

Air leaks into the condenser are tested by cutting off the vacuum pump from time to time, so that drop in vacuum may be observed. A slow reduction, say 1.0 in. in 45 minutes is considered to indicate a tight condenser. If the rate of reduction is excessive, the joints are tested with a candle or open flame.

Statement from Los Angeles Gas & Electric Corporation

This company has experimented with lined condenser tubes and has developed a machine for obtaining a smooth uniform thickness of coating. Five 4-ft. sections of condenser tubes having soft metal linings were installed in the Seal Beach condenser Se-t. 11, 1926. These tubes have had approximately five months' service with sea water circulated through them. The temperature has averaged approximately 67.2 deg. F. This water carries a small amount of sand and also about 4.7 c.c. of oxygen per liter. These five tube sections are lined as follows:

Two tubes lined with pure lead.
Two tubes lined with pure tin.
One tube lined with "half-and-half" solder.

The tin-lined tubes appear to be in not as good condition as the lead-lined and solder-lined tubes. No deterioration of the lining can be discerned in these latter tubes. The tin-lined tubes show what appear to be very small spots of light-colored scale, which may have pits beneath them. Also, at the entrance-end there are larger pits for a distance of about two in. All five tubes are expanded into the tube sheet and belled. It is possible that the tin lining suffered greater deterioration from the expanding process than did the lead and solder linings, which may account for the large pits mentioned.

In making up these sections, standard 1-in. (o.d.) 16-gage seamless brass tubes about four feet long were bored out to approximately one-half of the original thickness and the lining put in to bring them back to the original thickness. A special machine was developed with which to do this work. It consists of a 2-hp., 3,600-r.p.m. motor, with shaft extended through to take a pulley on each end. These pulleys drive two heavy hollow-steel spindles mounted on annular ball bearings and supported in cast-iron brackets mounted on an "I" beam. Tubes are spaced about eight inches apart and are carefully lined up. The bores allow a condenser tube to slip through with a minimum of slack. One of the spindle bores has a keyway cut its full length into which is fitted a splined plug on the back end of which is mounted a small ball thrust bearing.

The condenser tube to be lined has a lip rolled inward at each end which is the exact bore of the lining desired. This acts as an overflow lip and determines the thickness of metal which can remain in the tube under the laws of centrifugal force. This tube is swabbed with cut acid (chloride of zinc) and placed in the steel spindle having the splined bore. The proper amount of lining metal is placed in the tube in the form of a wire or ribbon. The tube is followed by the splined plug which forces the tube ahead of it. The plug is fed either by a lever or a screw.

A gas torch is placed in the 8-in. gap between the ends of the steel tubes and the condenser tube is fed through the flame, melting the lining material. The centrifugal force spreads it. After passing through the flame the tube is cooled by a small stream of water just before entering the bore of the second spindle. The tube sections are turned down on one end for about one-half their thickness and for about one inch of length and sweat into a counterbore in a standard tube.

No tests have been made to determine the heat conductivity, and there is no data as to probable costs of lining. It is believed that if the life of the tube can be proved to be lengthened suffciently a machine can be developed which will do the work at a cost that will justify its use. It is believed also that by lining thin copper tubes the heat conductivity will compare favorably with that of standard brass tubes.

Experiments are being conducted with several condenser tubes in the cooling tower at the Alameda Street steam plant. The object of the experiments is to try to determine why copper tubes work successfully at Alameda Streeet plant but not at Seal Beach plant.

Statement from Southern California Edison Company

A study has been made of the operation of the three largest condensers at the Long Beach steam plant, those used with the two 35,000 and one 50,000-kw. units. Principally, only the 35,000-kw. turbo-generator No. 8, has been reported upon in the following paragraphs. The condenser has 55,000 sq. ft. of cooling surface, two passes, and two circulating pumps, each of 38,000-gal. per min. capacity.

Establishing Standards of Operation

In order to establish standard operating conditions the most economical operation of the circulating pumps were determined first. In this, consideration was given to the relation between load, turbine back pressure, injection-water amount and temperature, and power requirements of the pumps. The curve in Fig. 1 shows the result of these investigations. For load and injection-water temperature conditions falling to the right of this curve two pumps should be used. For conditions falling to the left of the curve one pump only is

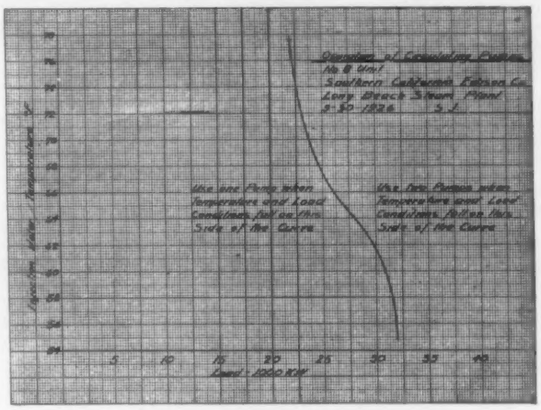

Fig. 1. Operation of circulating pumps, No. 8 unit.

needed. Relations between load and back pressure for different injection-water temperatures for a clean and tight condenser are illustrated in Fig. 2.

By these two curves the standard operating conditions of the condenser are established. The daily variations from this standard are plotted on a curve sheet, Fig. 3, reduced to a basis of 40,000-kw. load and 65-deg. injection-water temperature and where the standard back pressure is 1.25 in. mercury. The area between the 1.25-in. Hg. line and the actual curve represents a loss that is dependent upon the cleanliness and tightness of the condenser. The loss cannot be avoided completely because of resultant excessive cleaning cost, but the minimum combined expense of low vacuum and cleaning can be predetermined.

Determination of Most Economical Time Interval Between Cleanings

Analysis of the back-pressure curve, Fig. 3, shows that the pressure immediately after a cleaning climbs at a fairly uniform rate for the first month or so. If the tube deposits are allowed to accumulate the increase becomes more rapid, but with frequent cleanings the

assumption of a linear relation between time and back pressure is justified. It can be shown that the most economical time interval between cleanings is

$$t = \sqrt{\frac{2CT}{L}}$$

days, where C = cost of cleaning in dollars, T = days of time required for the vacuum to drop 0.1 in. Hg., and L = 24 hr. cost in fuel due to 0.1 in. Hg. low vacuum. By using the most economical time interval (t) the daily average cost of cleaning and low vacuum becomes a minimum, or $\frac{2C}{t}$ dollars.

For the turbine in question, T = 43 days. The value of L depends upon the load and can be calculated from curve 1, Fig. 4, showing the cost per hour of 1-in. drop in vacuum.

The cleaning cost C includes the cost of labor and material employed in cleaning and of resulting disturbances in operation. The water box on this condenser is divided and it is possible to clean half of the condenser

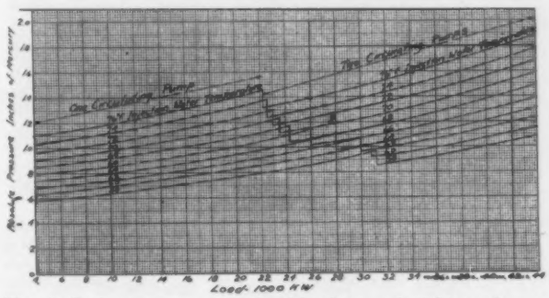

Fig. 2. Back pressure expected with clean and tight condenser, No. 8 unit.

while the other half is in operation. This necessarily would cause an increase in back pressure, raising the cleaning cost C. Curves 2 and 3, Fig. 4, show the effect on the vacuum resulting from cutting out one-half of the condenser, and the cost of additional fuel required by the vacuum drop. For instance, the additional hourly cost resulting from cleaning the condenser with a 40,000-kw. load on the unit would be $6.14.

Analysis of Tubes and Tube Deposits

Condenser tubes are of admiralty brass, 1-in. outside diameter, No. 16 B.W.G. An analyzed sample contained 71.5 per cent copper, 27.1 per cent zinc and 1.4 per cent tin.

The inside of the condenser tubes accumulate a layer of brown deposit covering a green, hard scale. The outside of the tubes have a black covering that looks and feels like soot. Chemical analyses of these deposits are given in Table I. The green scale is a mixture of hydroxides, oxy-chlorides and basic carbonates of copper and zinc, together with some calcium sulphate and oxide or hydroxide of iron, silica and organic matter. The brown deposit is very similar to the green deposit except for the large percentage of iron (ferric hydroxide from the electrolytic protective system) which gives it a brown color. The brown deposit is slimy when wet, hard and brittle when dry, and can be washed off. The

TABLE I—Chemical Analysis of Tube Deposits.

Substance	Black	Green	Brown
Moisture (loss at 105°C)	5.1%	5.3%	6.7%
Organic and volatile matter	12.3	19.0	25.3
Insoluble matter (silica, etc.)	1.9	8.1	11.7
Copper (Cu)	52.8	20.9	22.0
Zinc (Zn)	11.6	24.0	7.6
Iron Oxide (Fe_2O_3)	3.1	2.1	13.8
Calcium (Ca)	0.9	0.6	1.4
Sulphates (SO_4)	0.4	3.2	2.3
Chlorides (Cl)	1.3	2.8	5.7

black deposit on the tube outside is principally copper and zinc oxide from the tube itself, and contains a certain amount of organic matter, probably oil.

Cleaning of Tubes

Cleaning of the outside of the condenser tubes was tried with several solutions on tube samples. A 10-per-cent solution of oakite at 100 deg. C, boiling for 30 min. had no effect. A 1-per-cent solution of hydrochloric acid, HC1, 1 min. at 100 deg. C., had good effect as did a 10-per-cent solution, 5 min. at 20 deg. C. A 10-per-cent solution of ammonium chloride, NH_4C1, 15 min. at 20 deg. C, had no effect; 5 min. at 100 deg. C, fairly good; 15 min. at 100 deg. C, good. A 10-per-cent solution of nitric acid H_2NO_3, one minute, removed about half of the deposit. After 5 min. all deposit was removed.

The best solution probably would be 1 or 2-per-cent hydrochloric acid with 5 or 10-per-cent ammonium chloride, used lukewarm. Care should be taken not to overdo the treatment, as anything that will affect the tube deposits also will affect the tube itself. This outside cleaning has not been tried out yet in actual practice.

Several cleaning methods have been used on the inside of the tubes: compressed air, rubber plugs, sandblasting and washing with high-pressure water. The compressed air method is the quickest and cheapest. The whole condenser can be blown thoroughly in 11 hr., with five men and the work done while the unit is operating. If the tubes are wet a major part of the brown deposit is removed. It has little or no affect on dry tubes. The cost of cleaning is $65.

Cleaning with rubber plugs is more thorough and a better vacuum is obtained after cleaning. Plugs of conventional design are supposed to expand slightly in diametrical direction when pressure is applied, thus giving a tight fit. It is doubtful if any of the green scale is removed by this method. The time required for shooting the plugs with five men is 21 hr., at a total cost of $105 and with the condenser shut down.

Sandblasting is the most effective, but also the most expensive method that has been tried up to the present time. Prior to the cleaning operation some experiments were conducted on old, discarded condenser tubes to determine the influence of the several factors, such as nozzle design, quantity of sand, and air pressure.

The simple equipment used is an air jet where the air velocity causes a suction at the sand-inlet opening of the mixing chamber. The mixture of sand and air is blown into the condenser tube through a nozzle of suit-

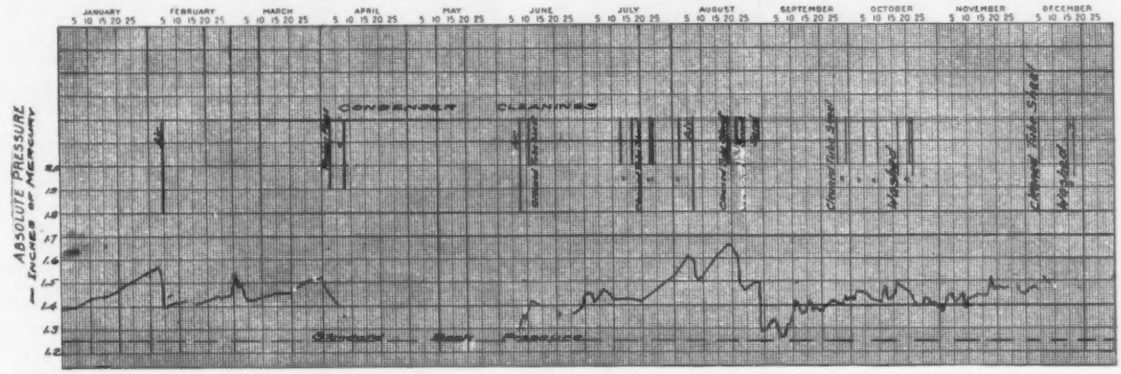

Fig. 3. Daily back-pressure curve for the year 1926, reduced to 40,000-kw. load and 65-deg. F. injection water No. 8 unit.

able dimensions. It was found by these experiments that high sand velocity is an essential element in uniform cleaning of the tube. Therefore air pressure should be as high as possible. Uniform cleaning was unobtainable with an air pressure below 80 lb. The highest pressure obtainable, 100 lb., gave the best results.

Several nozzle diameters were tried with 3/16-in. opening on the air nozzle tip. A cylindrical nozzle of ⅜-in. diameter was found to be most effective. A smaller nozzle did not pass sufficient volume and a larger nozzle had a tendency to clean too much of the

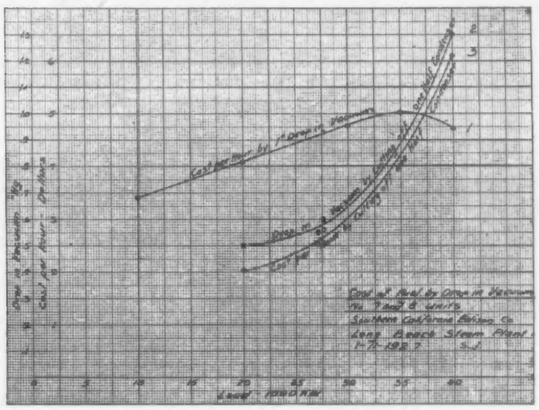

Fig. 4. Cost of fuel by drop in vacuum: effect of cutting out one-half of the condenser, No. 8 unit.

inlet part and not enough of the outlet part of the condenser tubes, which are of 1-in. o.d. No. 16 B.W.G., admiralty brass, 20 ft. 3 in. long. Generally, it was found that the sand stream should have maximum velocity and minimum diameter so as to give each sand particle a good cutting effect distributed over the whole tube length. The sand particles should have a certain mass. Very fine sand, therefore, is not as good as coarser sand. Sand particles should be as sharp as possible. Beach sand was used mostly in the experiments, and also in the condensers.

The weight loss of the tubes resulting from blowing was determined. A typical weight-loss curve in relation to the amount of sand blown is shown in Fig. 5. This curve was obtained with a ⅜-in. nozzle, 100-lb. air pres-

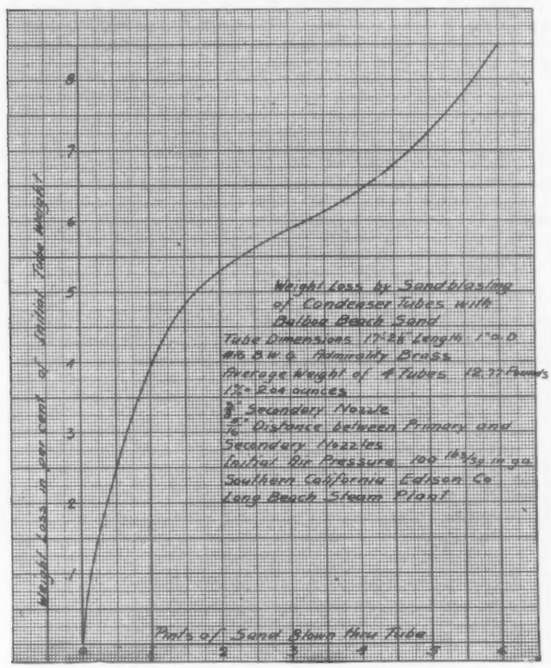
Weight Loss by Sandblasting of Condenser Tubes with Balboa Beach Sand
Tube Dimensions 17'-2⅝" Length 1" O.D. #16 B.W.G. Admiralty Brass
Average Weight of 4 Tubes 12.77 Pounds 1%=2.04 ounces
⅜" Secondary Nozzle
5/16" Distance between Primary and Secondary Nozzles
Initial Air Pressure 100 lbs/sq in ga.
Southern California Edison Co
Long Beach Steam Plant
Weight Loss in ounces per cent of Initial Tube Weight
Pints of Sand Blown thru Tube

Fig. 5. Weight loss by sandblasting of condenser tubes, ⅜-in. nozzle, initial air pressure 100 lb.

sure and 5/16-in. distance between the primary and secondary nozzles. Four tubes were sandblasted each of 1-in. o.d., No. 16 B.W.G., 17 ft. 2⅛ in. long, with an average tube weight of 12.77 lb. Balboa Beach sand was used. The first part of the curve, after blowing one pint of sand, shows a loss of 0.8 oz. or 0.4 per cent of the tube weight. Here is where the brown scale deposit, and some of the looser green scale is removed. The second period, up to four pints of sand, shows an average of 0.16 oz. or 0.08 per cent per pint. This part of the curve indicates the removal of hard scale and copper from the dezincified surface, and the weight loss

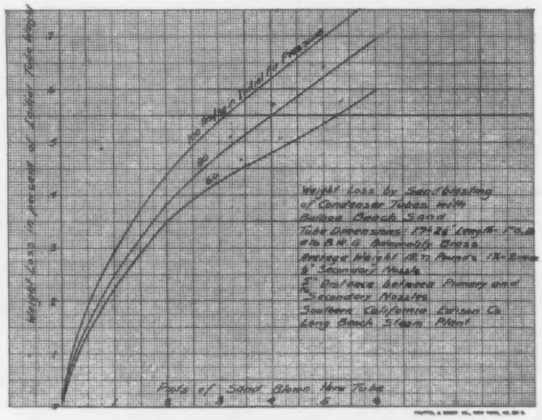
Weight Loss by Sandblasting of Condenser Tubes with Balboa Beach Sand
Tube Dimensions 17'-2⅝" Length 1" O.D. #16 B.W.G. Admiralty Brass
Average Weight of 4 Tubes 12.77 Pounds
⅜" Secondary Nozzle
5/16" Distance between Primary and Secondary Nozzles
Southern California Edison Co
Long Beach Steam Plant
Pints of Sand Blown thru Tube

Fig. 6. Weight loss by sandblasting of condenser tubes, ½-in. nozzle, initial air pressures 60, 80 and 100 lb.

per pint of sand is small. The last part of the curve shows again a more rapid loss of 0.22 oz. or 0.11 per cent per pint of sand. A certain amount of brass is taken away in this period, as most of the scale has been removed in the second period. The total weight loss after six pints of sand averaged 1.72 oz. or 0.86 per

TABLE II—Cleaning of No. 8 Condenser
Unit shut down while cleaning

Item	Method of Cleaning	Compressed Air	Rubber Plugs	Sand Blasting	Washing
1	No. of men required for cleaning..	5	5	10	4
2	Time required for cleaning, hours...	11	21	39	15
3	Cost of labor and material = C.. ..	$65	$105	$410	$65
4	Back pressure obtained after cleaning, reduced to 40,000-kw. Load and 65°F. injection water, in. Hg..	1.40	1.35	1.29	1.40
5	Standard back pressure, in. Hg....	1.25	1.25	1.25	1.25
6	Difference between actual and standard back pressure, in. Hg.....	.15	.10	.04	.15
7	Time required for vacuum to drop 0.1 in. Hg. after cleaning is 43 days = T.				
8	24 hours loss in fuel with 0.1 in. Hg. low vacuum at 40,000-kw. load = $11.32 = L.				
9	Most economical time interval between cleanings = $t = \frac{2TC}{L}$ days ..	22.2	28.2	55.6	22.2
10	Daily average cost of cleaning plus low vacuum based upon best vacuum obtainable = $\frac{2 \times C}{t}$	$ 5.85	$ 7.44	$14.73	$ 5.85
11	Daily cost due to difference between obtainable and standard back pressure...	16.95	11.32	4.53	16.95
12	Total cost of cleaning and low vacuum..	22.80	18.76	19.26	22.80

cent. Tubes were reasonably clean over the whole tube length, but always cleanest at the inlet end.

The characteristic of three distinct divisions in the cleaning curves was not always obtained, but was very pronounced with tubes that were well cleaned. Figure 6 shows the effect of variation in air pressure with a ½-in. nozzle.

From the typical weight-loss curve, Fig. 5, it would appear that four pints of sand were necessary for a good cleaning job. However, at that rate a 10,000-tube condenser would require 30 tons of sand, 800 man-hr. and cost $1,300. Therefore it was decided to use only one pint per tube, as the first pint is the most effective. The blowing was done with two groups of five men each, two nozzles per group. The total time required for one condenser was 39 hr., including the time required for removal of the sand after blasting. The cost

was $410. Nine tons of sand were used. The nozzles, which were made of tool steel, were worn out of shape after blowing from 300 to 400 tubes.

The washing of the tubes is done with water at 130-lb. pressure through ⅝-in. nozzles. Four men do the work in two working days, or 15 hr. The average blowing per tube is 15 sec.

Cost of Cleaning

These four cleaning methods are compared in Table II. Item No. 4 shows the back pressure obtained after cleaning. This is a very important factor because to a large degree it determines the value of the cleaning methods. The cost alone is not indicative of cleaning economy. The most economical time interval between cleanings is calculated in item No. 9, according to the method described above. It follows that the condensers either should be blown or washed every 22 days, cleaned with plugs every 28 days, or sandblasted every 56 days. By using these time intervals the daily average cost is $5.85 for blowing or washing, $7.44 for cleaning with plugs, and $14.73 for sandblasting (item No. 10). To this cost must be added the loss due to the difference between the operating vacuum obtainable and the standard vacuum obtainable with a clean condenser (item No. 11). The total cost that gives a true value of the merits of the respective cleaning methods is arrived at in item No. 12.

The most economical cleaning method according to this analysis is rubber-plug cleaning with a daily cost of $18.76. Sandblasting is close behind with a cost of $19.26. Compressed air and washing cost the same, $22.80 per day. The values are compiled for cleaning with the unit shut down so that no loss is charged to low vacuum with one-half of the condenser shut down. Table III has been prepared to show the costs with the unit in operation while cleaning. The economical time intervals have been lengthened (to 70 days in the case of sandblasting, with 40,000 kw. load) and the costs have been raised. The relative merits of the methods

TABLE III—Cleaning of No. 8 Condenser
Unit in operation while cleaning

Item	Method of Cleaning	Compressed Air	Rubber Plugs	Sand Blasting	Washing
1	Cost of labor and material, 30,000-kw. load while cleaning	$65.00	$105.00	$410.00	$65.00
2	Cost of low vacuum due to half condenser being down, $3.03 per hr.	33.30	63.60	118.20	45.40
3	Total cost	98.30	168.60	528.20	110.40
4	Most economical time interval between cleanings, days	27.3	35.5	63.0	28.8
5	Daily average cost of cleaning	$ 7.20	$9.50	$16.78	$7.64
6	Daily cost due to excess back pressure after cleaning	16.95	11.32	4.53	16.95
7	Total cost of cleaning and low vacuum, 40,000-kw. load while cleaning	24.15	20.82	21.31	24.59
8	Cost of low vacuum due to half condenser being down, $6.14 per hr.	67.50	129.00	239.00	92.10
9	Total cost	132.50	234.00	649.00	157.10
10	Most economical time interval between cleanings, days	31.7	42.1	70	34.5
11	Daily average cost of cleaning	$8.36	$11.12	$18.56	$9.10
12	Daily cost due to excess back pressure after cleaning	16.95	11.32	4.53	16.95
13	Total cost of cleaning and low vacuum	25.31	22.44	23.09	26.05

Note—Items 5 and 11 include the cost of low vacuum due to dirty condenser between cleanings.

employed remain unchanged, however, with the exception of high-pressure washing which shows up least favorably. The relation between frequency and cost of cleaning, and load is illustrated on the curve of Fig. 7.

Subsequent to the rubber-plug cleaning of No. 8 unit florite nozzles were installed. These will prevent further use of this method. The best way, therefore, will be to employ sandblasting with intermediate compressed-air cleanings. The florite nozzle will protect the inlet-end of the tube, which otherwise would be subject to the greatest wear. A new florite nozzle will stand 90 pints of sand before the edge starts to break down.

Cost of Operation

By sandblasting the condenser as indicated, the total annual **standard** cost would have been $4,100 if cleaned with the unit shut down, and $4,800 if cleaned with a 37,000-kw. load (average for 1926). Figures are based upon the actual operating time of 5,187 hours and represent the minimum obtainable cost of cleaning and low vacuum. The actual expense of cleaning and low vacuum was $5,987.24. The more than $1,800 difference between the actual and standard costs is due principally to previous lack of data on the cleaning methods. This data now is available and it is expected that the current

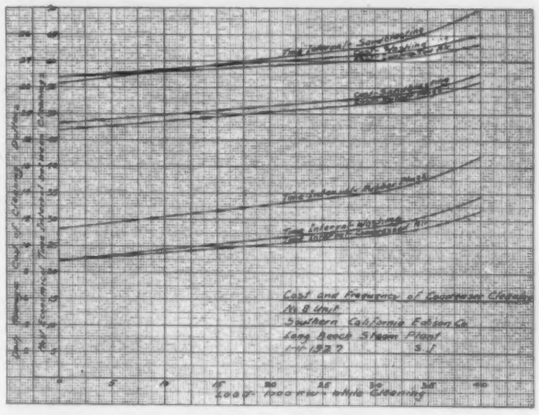

Fig. 7. Cost and frequency of condenser cleaning, No. 8 unit.

year will show a closer relationship between the two figures.

Annual maintenance expense of No. 8 condenser for 1926, including all losses caused by the maintenance work, follows in detail:

1.	Condenser cleaning	$ 960.04	
2.	Tube sheet cleaning	92.42	$ 1,052.46
3.	Testing for leaks		438.41
	Florite Nozzles:		
4.	Material	5,407.00	
5.	Installation (labor)	510.00	
6.	Replacements	645.05	6,562.05
	Electrodes:		
7.	Replacements	1,095.68	
8.	Electric current	12.00	1,107.60
	Total annual cost		$ 9,160.52
10.	Annual cost of fuel, caused by the vacuum being below standard at all times		$ 5,027.20
11.	Total annual cost of maintenance and low vacuum, No. 8 condenser, 1926		$14,187.72

The expense of cleaning and low vacuum referred to at the beginning of this section is the sum of items No. 1 and No. 10. Item No. 10 is obtained by integration of the back pressure curve of Fig. 3, a detailed tabulation of which is given in Table IV.

TABLE IV—No. 8 Unit Operation and Cost of Low Vacuum.

Month 1926	Hours Operated	Gross Load, Kw.	Average Load, Kw.	Av. Back Pressure, in., Hg.	Excess Back Pressure, in., Hg.	Excess Back Pressure, Hours	Cost per in. Hg. per Hr.	Total Cost
1	2	3	4	5	6	7	8	9
Jan.	728-35	29,525,200	40,400	1.45	.20	146	$4.67	$ 682.00
Feb.	456-40	14,665,000	32,150	1.44	.19	86.6	4.93	427.00
March	428-47	13,282,000	31 000	1.46	.21	90	4.85	437.00
April	57-10	707,900	13,960	1.43	.18	10.3	3.68	37.90
May								
June	50-08	1,687,900	33,700	1.37	.12	6.1	5.00	30.50
July	613-10	21,543,300	35,100	1.46	.21	129.3	5.03	652.00
Aug.	695-52	26,882,400	38,600	1.55	.30	209.0	4.87	1020.00
Sept.	700-50	27,337,300	39,100	1.37	.12	84.1	4.82	406.00
Oct.	733-00	27,937,800	38,100	1.44	.19	136.3	4.90	668.00
Nov.	635-55	25,852,610	40,700	1.44	.19	123 0	4.60	566.00
Dec.	86-50	2,876,930	33,300	1.48	.23	20.2	4 98	100.80
Total.	5186-57	192,386,340	37,000					5027.20

Note—Col. 6 = Col. 5—1.25 in. Col. 7 = Col. 2 x Col. 6.

Tube Sheet and Tunnel Cleaning

Intake tunnels for the circulating water at Long Beach steam plant are approximately 1,200 ft. long. Average water velocity 3.7 ft. per sec. under full operation of No. 2 plant. The tunnels are of concrete with a square cross-section. The tunnel intake is located at the turning basin between Terminal Island and the mainland and dredging activities going on at the channel inlet cause a large amount of sand to be drawn into the tunnels at times. Last spring it was found that sand and fine silt had been deposited in the tunnel bottom at a rate of 4½ tons per day for four months. This sand is not considered very harmful to the condenser. The marine growth has much more effect upon the operation if allowed to accumulate because it clogs the tube sheets at the inlet end. In the past year an aggregate of 2.25 miles of intake tunnels have been cleaned, a total interior area of 7.1 acres. The actual combined tunnel length is one mile and the interior surface 3.2 acres. Most of the tunnels have been cleaned several times. The cost of this work was about $2,500, $0.212 per foot of tunnel length, or $0.0071 per sq.ft. of interior tunnel surface. The tunnel cross-sections vary from 7 x 7 ft. to 3 x 7 ft., with intermediate sizes.

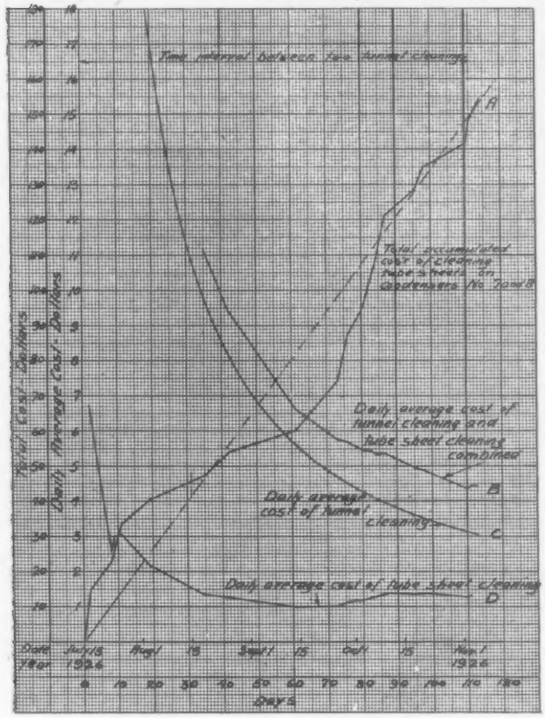
Total accumulated cost of cleaning tube sheets on condensers No 7 and 8
Daily average cost of tunnel cleaning and tube sheet cleaning combined
Daily average cost of tunnel cleaning
Daily average cost of tube sheet cleaning
A
B
C
D
Days

Fig. 8. Determination of most economical time for tunnel cleaning, No. 7 and 8 units.

Condition of the condenser tube sheets is dependent upon the cleanliness of the tunnels. Dirty intake tunnels will cause a rapid clogging of the tube sheets. Too much economy in tunnel cleaning will cause excessive cost in the tube-sheet cleaning. The curves in Fig. 8 illustrate the relation between the two variables. The cost of cleaning the tunnels to No. 7 and 8 Units was $343.10. The daily average of this amount, $343.10 divided by the number of days elapsed since the last cleaning, forms an hyperbolic curve in relation to time, curve C, with the date of the last cleaning, July 15, 1926, as zero. The accumulated cost of tube-sheet cleaning also has been plotted, curve A, and the daily average of this item, curve D. The sum of the two averages, C plus D, is plotted as curve B. This curve, B, will slope first downward, reach a minimum, and then rise.

The tunnels should be cleaned when the minimum or horizontal stage has been reached, which, on the chart is around Nov. 2. It is evident that the total daily average cost, curve B, will not reach a minimum until curve D begins to show an upward trend. This will happen when the tangent to curve A intersects the abscissa on the positive side of zero, to the right of the date, July 15, in the present case. Without knowing the exact cost of the tunnel cleaning, the cleaning time can be approximately determined by plotting curve A alone, or the accumulated cost of the tube-sheet cleaning, and watching the slope of this curve. But, as the cost of each tube-sheet cleaning is very nearly a constant figure, it will be sufficient for all practical purposes to plot the accumulated number of tube-sheet cleanings as a function of time. The pressure drop of the circulating water in the condenser is measured with a mercury U-tube. Whenever obstructions on the tube sheet cause the pressure drop to exceed 14 in. with two pumps running, the tube sheet is cleaned by hand-picking. The normal pressure drop averages from 10 to 11 in.

Coats of "Everlastic" and "Bitumastic asphaltic paints were applied to sections of a new tunnel with a marked beneficial effect in retarding marine growth. The effect may not last long, however, and the proposition is too expensive to have any economical value. One painting costs as much as six tunnel cleanings.

Tube Leaks

The tube leaks developed in the two 35,000-kw. condensers are few. Until January, 1926, after a year of service, the No. 7 condenser had 12 tube leaks and No. 8 had 3. Each condenser has 10,504 tubes. These leaks were caused principally by burred edges on short entrance nozzles that were driven in at the tube inlets. In the year 1926, after the installation of long entrance florites nozzles covering up the pitting, the condensers developed two leaks each. These nozzles are 8 in. long, extend 4½ in. into the tubes, and the down stream edges are rolled against the tube walls. The nozzles proper stand up well, but the downstream edges wear out and become ragged after six months of service in the first pass, and after 10 to 12 months in the second pass. The worn nozzles have been cut ¼ in. shorter, a new edge reamed, and the nozzles reinserted 5 in. into the tubes. At that rate the average life of a nozzle should be two or there years, and the average annual cost per condenser on this item should be in the neighborhood of $3,000 including maintenance.

The presence of condenser leakage is discovered through a recording salinometer. Leaks are located by raising slowly the water level in the water space of the leaky half of the condenser, while the unit is operating. When the water-level has reached the leak the salinometer records a sudden increase in salinity of the condensate.

Electrolytic System of Protection

The electrolytic system of protection consists of 16 anodes placed against the tube sheets in each end of the condenser. Direct current of 7 volts, 80 amp. per condenser, is supplied from two parallel-connected motor-generator sets.

Anode terminals are cast-iron lugs weighing 31 lb. each. The lugs on one condenser lost 50 per cent of their weight after five months of service, an average of 2.9 lb. per day for the whole condenser. Lugs on another condenser showed an average daily loss of 1.4 lb. in two months after the insulation against leaks to the waterboxes had been improved. The reduction in volume is preceded by a gradual softening of the surface, about ¼ in. deep. There is a sharp limit between the soft and the original material, evidenced by the fact that the soft matter falls off in flakes when dry. The surface matter contains 12.27 per cent carbon and only 43.9 per cent iron, which indicates that the pure iron has been removed by galvanic action. Ordinary cast iron contains 3 or 4 per cent carbon.

Air in Condenser

The amount of air removed from one of the 35,000-kw. condensers has been measured through a ½-in. orifice. No great variations were noted and no definite relation between load and air. The average amount is 1.8 cu.ft. per min. at 60 deg. F. and 29.92-in. mercury barometer reading. The temperature of the air-vapor mixture ranges from 102 to 150 deg. F., depending upon conditions of the steam to the jets and the condensate through the coolers.

Instruments for Boiler Room and Turbine Room*

The objectives set forth for this sub-committee for the year 1926-27 were:

1. To make a comprehensive survey of instruments used by member companies.

2. To determine those that have given complete satisfaction.

3. To determine operating troubles and remedies applied.

Fuel Instruments

Tank Gages—Oil-tank gaging is made by a steel tape or graduated rod, graduated to 1/16 in. Southern California Edison Company reports having an inclined-mercury-tube indicating gage, but it is not in service to date. The Los Angeles Gas & Electric Corporation reports having two of these instruments. Owing to the

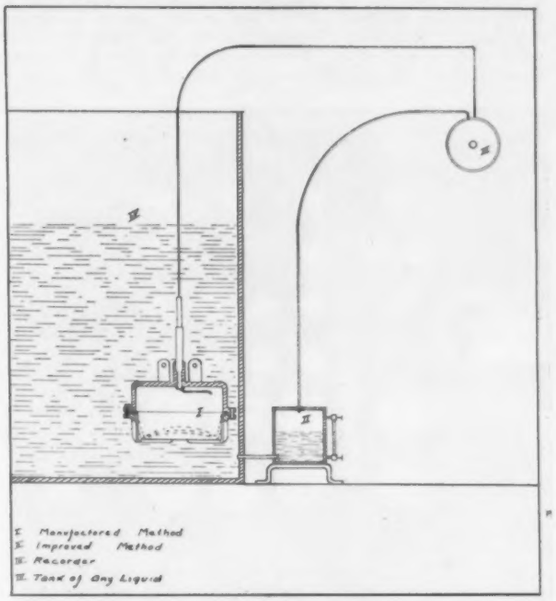

Fig. 1. Liquid-level gage used by Southern California Edison Company.

numerous errors in readings and the difficulty in keeping them properly maintained, they are not in use at the present time.

The Southern California Edison Company is using liquid-level recorders for recording the level of fuel oil in tanks. Two hours per month are required for calibration, as they must be adjusted for temperature and gravity. The San Diego company is using another type of liquid-level gages, which operate from pressure using a diaphragm and capillary tube. These instruments are very satisfactory and accurate within two or three per cent.

Oil Meter.—There seems to be a demand for a meter of a high degree of accuracy that can be depended upon to run and that automatically will take care of changes in temperature. Two types are reported in use. The only comments offered on the meter A were to the effect that it was not accurate over full range. The general complaint on meter B is that it is too sensitive to foreign particles, valves sticking and piston stopping on center.

When two meters are used, one for measuring the oil to the burners and the other for measuring the by-passed oil to the tank, trouble has been experienced by oil flashing into vapor under reduced pressure and meter reading too high by measuring the oil and vapor. This has been overcome partly by keeping the discharge meter under pressure. However, the Edison company reports having this type of installation on one boiler; it was checking against weighed oil within 0.3 per cent. The Los Angeles Gas & Electric Corporation has experienced about the same difficulty with this type of meter and also considerable difficulty with the integrating device not working properly. To date, this difficulty has not been solved. This company is equipped to measure fuel to the individual boilers, checking these totals back against tank gagings. Up to the present time results have been rather discouraging. The piston-type meter causes slight pulsations in the oil line that is thought by some to be objectionable.

Gas Sampling.—The Los Angeles Gas & Electric Corporation reports the use of a gas-sampling system. Gas is taken through a 1/32-in. orifice in the burner manifold of each boiler and led to gasometer. The amount of gas collected is proportional to the pressure on the manifold. The gas samples are used for determining the heat content and gravity for the past 24-hr.-period.

Calorimeter Recording.—The Southern California Edison Company reports the use of a recording calori-

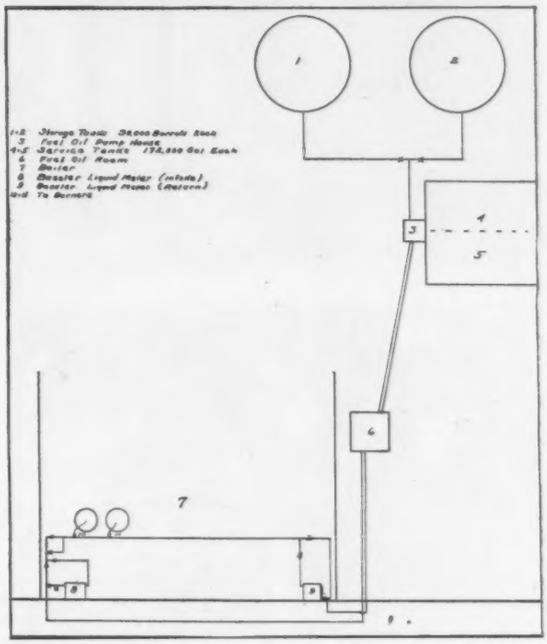

Fig. 2. Fuel-oil cycle, Southern California Edison Company, Long Beach plant.

meter and reports show four hours per month maintenance, this time being used in calibrating with hydrogen gas. The only trouble experienced was slime in the tank. This was corrected by using acid to overcome alkalinity.

Laboratory Calorimeter.—To get consistent results with either of the ones reported in use they must be used by a very careful laboratory man. Otherwise, results are likely to be erratic. It is the experience of the Los Angeles Gas & Electric Corporation that repeated results with gas may be obtained with less than 1 per cent variation, providing the calorimeter is kept clean and room temperature held constant.

Equipment for Measuring Fuel

None of the members rely upon oil meters for calculating the daily plant operations. Tank gagings at the beginning and end of the 24-hr.-period are used. This, in some cases, may mean an appreciable error. For instance, in a plant using 1,000 bbl. per day and measuring oil from one or more 50,000-bbl. tanks, an error of 1/16 in. would represent about 1 per cent error. For plants using less oil this error would be correspondingly

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* **Report of sub-committee.—F. R. Knight, chairman.** H. C. Bennett, P. E. Chapman, H. E. Fuqua, M. E. Mulkey.

In the preparation of this report the subcommittee has utilized the information by ten member companies in answering a 126-question questionnaire circulated by the subcommittee. The ten companies, operating steam plants, that returned answers were: Arizona Power Company, Central Arizona Light & Power Company, Desert Water & Power Company, Great Western Power Company, Hawaiian Electric Company, Ltd., Los Anegles Gas & Electric Corporation, Pacific Gas and Electric Company, San Diego Consolidated Gas & Electric Company, San Joaquin Light & Power Corporation, Southern California Edison Company. Eleven other answers were received but pertained to water-power, diesel-engine, and other plants not pertinent to the subject. Eleven companies did not answer.

larger, while on plants using more the error would be negligible.

Is Heating Value Taken by Calorimeter or Analysis?—Four members obtain heating values by calorimeter, three from analysis, and three use an arbitrary figure of 18,500 B.t.u. per pound of oil. It is assumed that, where heating value is obtained from analysis of the gas or oil, samples are submitted to some testing laboratory and that heating values are computed from the constituents of the fuel. This always differs somewhat from that found by a calorimeter.

Do You Use the "Higher" or "Lower" Heating Value?—All that are not using an arbitrary value are using the "higher."

What Corrections do You Make for Hydrogen Losses?—All report none, except in boiler test or making heat balance.

What Is Your Standard Barrel of Oil?—This question brought a variety of answers as follows: 6,345,324 B.t.u; 6,271,440 B.t.u. corrected to 5,908,460 B.t.u.; 6,105,000 B.t.u.; 18,500 B.t.u. per lb.; 18,500 B.t.u. per lb.; 18,300 B.t.u. per lb.; 42 gal. per barrel × 8 lb. per gal. × 18,600 B.t.u. per pound = 6,249,600 B.t.u. per bbl., and 42 gal. per bbl. × 7.788 lb per gal. × 19,089 B.t.u. per lb. = 6,247,536 B.t.u. per bbl.

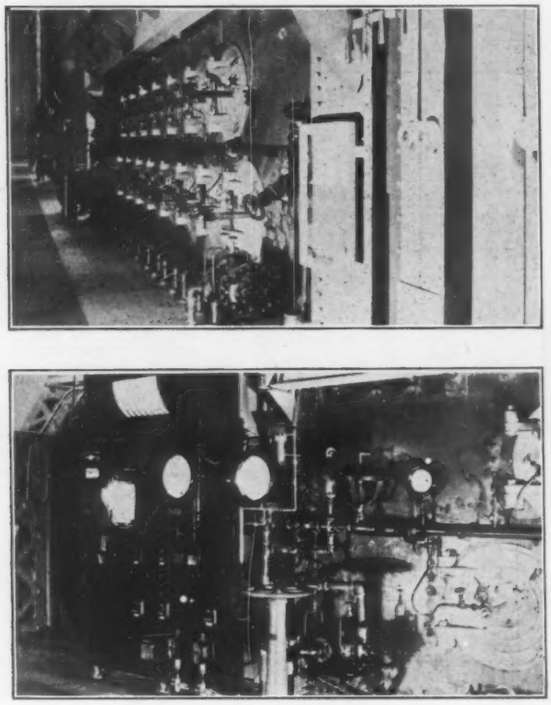

Fig. 3. Boiler panel and oil meter installation, No. 45 boiler, Long Beach.

These answers show clearly the necessity of comparing plants upon a B.t.u. per kw-hr. basis, instead of upon a kw. per bbl. basis as so many have done in the past; also that heating value and gravity should be obtained accurately.

How Do You Correct Gas Into Its Oil Equivalent?—Three companies, only, report using gas. All report by dividing calorific value of gas per cu.ft. into standard barrels.

How Often Do You Make Gravity and Temperature Corrections on Your Gas Meters?—All members report making daily corrections. The Los Angeles Gas & Electric Corporation has found that this is essential as the gravity of the gas as well as the B.t.u. content may change consdierably in 24 hr. A 2-per-cent change in gravity makes a 1-per-cent change in the meter constant.

How Do You Measure the Temperature of Your Oil Tanks? How Often?—One company reports taking temperature every two hours, but does not say whether this is on feed tanks or main storage. The great majority only take temperature and make corrections at the time of receiving oil shipments. This is done with three thermometers, one each immersed in the top, bottom and middle oil. The average of the three is taken. One reports taking temperature measurements at the end of the month. This company evidently makes inventory of oil stock once a month, and takes temperatures at this time for corrections.

Flue and Furnace Instruments

CO_2 Recorders.—Five report the use of one certain type. The same general trouble is experienced by each: rubber tubing leaking, heaters leaking, direction valves sticking. These have been remedied by using a better grade of rubber or by using vaseline on direction valves. Time-lag in these instruments has been reduced by installing aspirators and by adding more solution to the absorption chamber, providing an overflow to take care of the increasing volume of solution. The Los Angeles Gas & Electric Corporation since last July has been using a solution of commercial lye which is perfectly satisfactory and much cheaper. The Southern California Edison Company had trouble with tubing clogging due to moisture in the sample when using an aspirator. The ⅛-in. copper tubing has been replaced with ¼-in. brass pipe. The Los Angeles Gas & Electric Corporation has experienced no trouble of this nature.

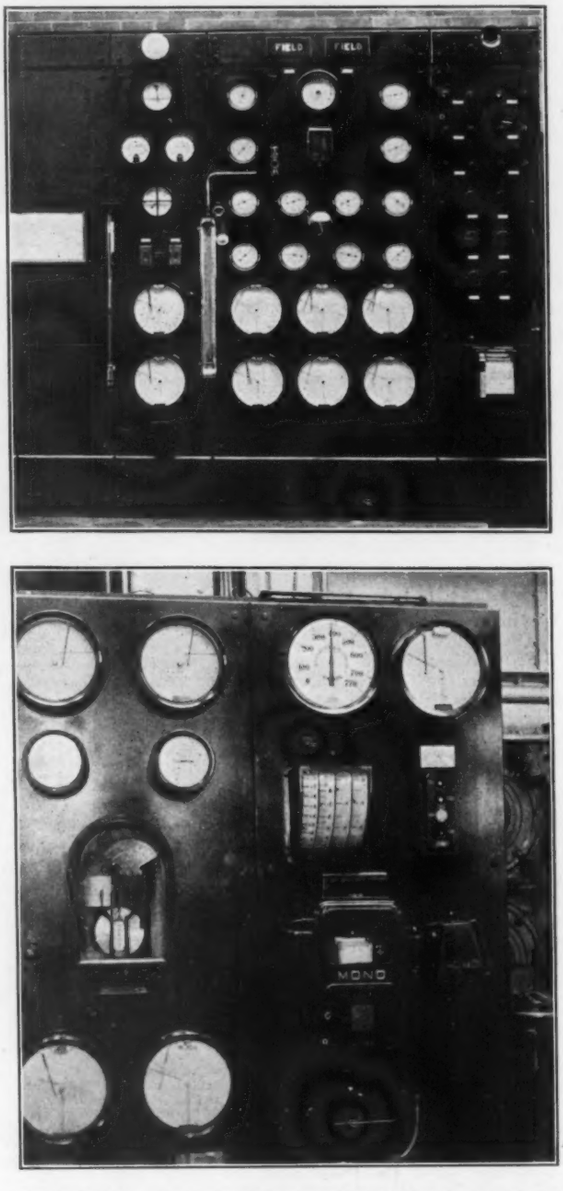

Fig. 4. Turbine-gage board (above) and individual boiler-gage board (below), Seal Beach station, Los Angeles Gas & Electric Corporation.

One company reports using a second make, but makes no comments. One company reports using a third make, motor driven, but no comments. The Pacific Gas and Electric Company reports a fourth kind installed. It has not been in use long enough to make a report. All report 15 to 30 min. per day maintenance. The balance are using portable apparatus.

Stack Temperatures.—Those in use are three well-known makes. One of these gives some trouble with the clutch slipping. Remedy: keep free from oil. Also trouble with commutator on the driving motor. Remedy: use synchronous motor.

Furnace Temperatures.—No permanent installations. Temperatures taken by thermocouples and optical pyrometers. No comments.

Steam Flow.—Not generally measured. Types used: equipment A showing per cent of boiler rating, equipment B, a flow meter. The Southern California Edison Company reports finding the orifice badly warped when inspected. Whether warping was due to welding of the Sargol joint in which they are installed or to high steam pressure has not been determined to date. It is suggested that the manufacturer make up the orifice or other differential-producing medium in a suitable thimble to fit into the pipe line where it is to be installed. This would eliminate all errors due to centering of orifice. The only comments on equipment B are the troubles experienced by contacts burning on the voltage regulator when installed where there is vibration. This has been remedied by using an oil dashpot.

Feed-Water Flow Meters.—There are eight different types in general use. No general complaint is voiced except with V-notched meters. A report from the Hawaiian Electric Company states that V-notch meters were inaccurate, required constant attention and caused intrainment of air in the feed water. The San Joaquin Light & Power Corporation reports the use of this same meter as satisfactory.

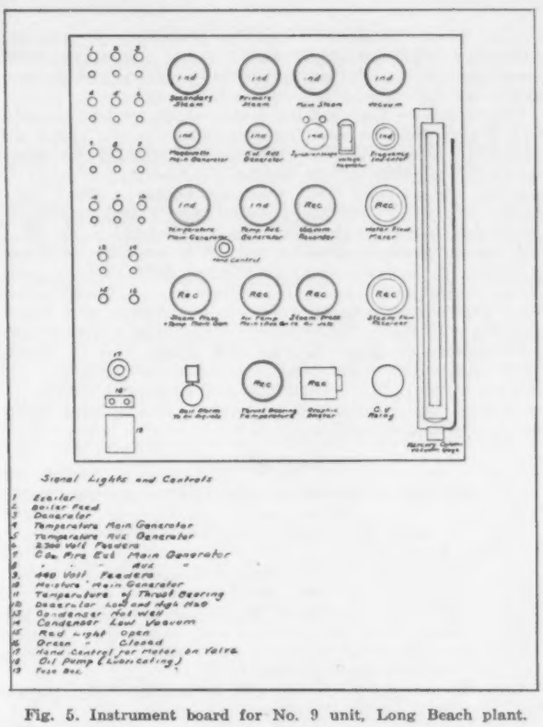
Signal Lights and Controls
1 Exciter
2 Boiler Feed
3 Generator
4 Temperature Main Generator
5 Temperature Aux. Generator
6 2,300 Volt Feeders
7 C.O. Fire Ext. Main Generator
8 " " Aux "
9 440 Volt Feeders
10 Moisture Main Generator
11 Temperature of Thrust Bearing
12 Generator Load and High Volt
13 Condenser Hot Well
14 Condenser Low Vacuum
15 Red Light Open
16 Green " Closed
17 Hand Control for motor on Valve
18 Oil Pump (Lubricating)
19 Fuse Box

Fig. 5. Instrument board for No. 9 unit, Long Beach plant.

Feed-Water Concentration Instruments.—One is in use by the Pacific Gas and Electric Company: a conductivity meter, homemade. The majority make periodic checks with silver nitrate.

Air in Feed Water.—Those using open feed-water heaters as a rule consider that system to be sufficient guarantee of no air. Some of those with closed systems are making daily checks of water continuously drawn from feed lines into airtight receivers. Others depend upon checks at intervals of a month or so by a local chemist.

Water-Level Indicating or Recording Instruments.—Majority depend upon the use of gage glasses. One company reports the use of liquid-level instruments. No trouble experienced.

State Troubles with Gage Glasses.—The higher-pressure plants report frequent breakage which is attributed to washers. The Hawaiian Electric Company reports the use of washers cut from cord casings which reduced the breakage.

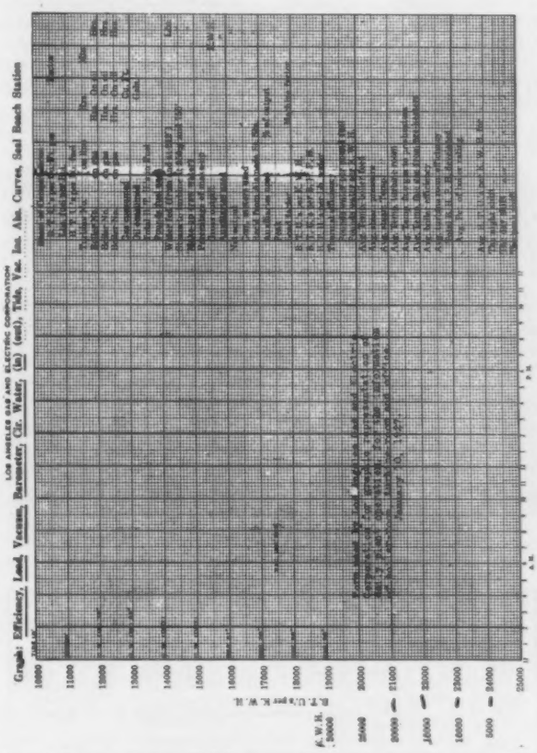

Fig. 6. Form used by the Los Angeles Gas & Electric Corporation for graphic representation of daily plant operation, for the information of the boiler room, turbine room, and office. Red, black, green, purple and yellow are used for the different curves.

Peepholes.—Most companies report the use of swing or slide openings or mica windows. The Los Angeles Gas & Electric Corporation has found the use of fused quartz in stainless steel frames very satisfactory.

Master Load Indicating Gages.—Wattmeters on individual machines and homemade affairs connecting with valve gear or manually controlled by the operators are the most common in use. No special comment. Master gages to be of maximum value should be seen from all parts of the boiler room and should be operated automatically.

Master Steam Gages.—The Southern California Edison Company reports having two in use. Type: pilot, range 330 to 390 and 360 to 390 lb. per sq.in. It has been found that lights used in this type of gage vary the readings to a serious extent, a 100-watt varying it 10 lb., a 40-watt, 7 lb, a 25-watt, 5 lb. It may be seen that a light of one fixed size must be used at all times, and that any burned-out lights must be replaced immediately or the readings of the gage will be out of calibration with actual pressures being measured.

Smoke Indicators.—The Pacific Gas and Electric Company uses lights and mirrors in the breaching of the boilers. No comment. The Los Angeles Gas & Electric Corporation is using one of special design, but that is of little use with gas and oil fires. Trouble: electrodes clog up. This company usually depends upon clear glass in the skylight through which the stack may be observed. No value at night.

Boiler Concentration.—The majority draw samples daily and check them with silver nitrate or a conductivity meter. It has been found that neither of these methods check with actual evaporation and weighing of the salt. The silver nitrate usually is a measure of the dissolved sodium chloride. The conductivity meter gen-

erally is calibrated to measure the dissolved sodium chloride, consequently when salts of a different valence are present this meter will not read correctly. The majority make checks daily for alkalinity as well as concentration. One company, in addition to daily checks, every third day sends a composite sample from all boilers to a local testing laboratory for complete analysis.

Feed Water Regulators.—Five companies report the use of a certain regulator. No special troubles are reported. The San Diego Consolidated Gas & Electric Company reports a second kind installed, but only recently, so there is no report. One company reports the use of a third type of water regulator. Service very satisfactory. Few repairs.

Regulators, Oil.—Three companies report the use of a certain regulator. This is a combination regulator on

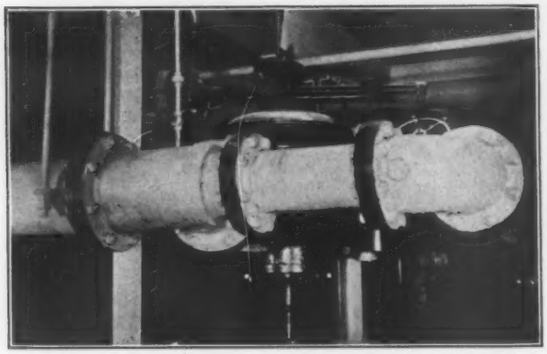

Fig. 7. Gas regulator used by Los Angeles Gas & Electric Corporation. Note the motor control for the sliding weight.

Gross K. W. H.
Net K. W. H.
Trans K. W. H.
Aux. %
Cu. Ft. Gas.
Bbls. of Oil
Total Fuel
K.W.H./Bbl.
Boiler Effic.

Fig. 8. Information form used by Southern California Edison Company for the information of the boiler room.

fuel oil, damper, and steam to burner. The chief trouble is replacing of diaphragms and sticking. The San Joaquin Light & Power Corporation reports the use of a second type of regulator which has given no trouble to date.

Speed-Indicating and Recording Instruments.—The usual vibrating-reed type is used. One company reports the use of a certain type. The trouble experienced is contacts burn; records do not show small variations. Another is using a second make. This type is operated from a d.c. magneto. This instrument has been operating six months and to date his given no trouble.

State the Maximum Boiler Concentration Allowed.—This question brought answers ranging from 50 to 400 gr. per gal. U.S. total solids.

How Is Daily Plant Operation Furnished the Boiler Room?—Only two or three members are furnishing this information to the boiler room. Forms illustrated in this report are used.

Condensate-Concentration Indicating and Recording Instruments.—Two types are in use. Both of these instruments are giving satisfactory results. No special comment.

Maximum Concentration Allowed.—Those reporting are from ½ to 3 gr. chlorides per gal.

State Devices for Measuring Condenser Air Leaks—Cubic Feet.—One company checks by timing the drop in vacuum with pump shut off. Another uses an orifice and manometer on the discharge of the air jet. Not considered very accurate.

General Comments.—No comments on displacement meters. The general comments on orifice and Venturi tubes are that after a number of years of service they show no appreciable wear, but where there are scale-forming materials the tubes will scale up and readings become inaccurate. One member reports that steam flow meters in series do not check very well. The results were discouraging as a discrepancy of 25 per cent usually existed.

Comments on Bridge, Thermocouple, and Optical Methods of Temperature Measurements.—One company reports the finding that an optical pyrometer checks

Fig. 9. Chart file; each folder contains charts for one week.

within 20 or 30 deg. F. with a radiation pyrometer. Thermocouples are fairly satisfactory. Another company reports a radiation pyrometer that has not proved ideal. That company favors the latter type.

Comments on Use and the Value of Boiler Compounds and Water Softeners.—One company reports these as generally very much overrated and should be used sparingly as they often create conditions worse than original unless used with scientific control. Two companies are using lime-and-soda softeners and find them fairly satisfactory. One has tried a patented compound, but up to present time is not in a position to pass opinion. A number are using other softeners to prevent formation of scale in evaporators. These have been entirely satisfactory for this purpose and have reduced materially the expense of cleaning evaporators.

Comments on Fire Alarms and Their Use in Plant Operation.—Only two companies have installed any of this equipment. These are installed in generators, fuel-oil rooms, and lubricating-oil rooms. No special comment is offered on this subject.

Recommendations

This sub-committee makes the following recommendations:

That the daily plant efficiencies be calculated upon a B.t.u.-per-kw-hr. basis.

That the kw-hr. be the total net, that is, the total gross generated less that used for plant auxiliaries, dividing this into the total B.t.u. content of the fuel above 60 deg. F.

That oil-tank measurements be made with a graduated rod, and results corrected to 60 deg. F.

That the weight of oil per gal. be taken from American Petroleum Institute tables.

That the B.t.u. per lb. be that actually obtained by calorimeter.

That the gas measurements be corrected daily for specific gravity and temperature.

That the B.t.u. content actually be obtained by calorimeter as the average for that particular day.

The above, as a standard method, would make comparisons more valuable and lead to better operation and improved equpiment. There still is great need for improvement in flow meters for measuring liquids and also there is need for some instrument for recording graphically the amount of non-condensible gases discharged from condensers.

Feed-Water Treatment*

Southern Pacific Company

The following information was obtained through the courtesy of A. H. Babcock of the Southern Pacific Company.

The Fruitvale station of the Southern Pacific Company has 12 boilers each rated at 645 hp., 200 lb. The boiler compound used is the compound covered by U.S. Navy specification 13C3c. It contains 76 per cent of soda ash.

Water in each boiler is tested twice a day. Compound is dissolved and pumped into each boiler separately in such quantities that the water in the boiler at all times is at least 2½ per cent normal alkalinity This concentration expressed in terms of soda ash and more familiar units is 1,325 parts per million or 77 gr. per gal. In terms of caustic soda it is 1,000 parts per million or 58 gr. per gal. A boiler contains about 6,500 gal. When a boiler is put into service, 85 or 90 lb. of compound is added to the water to bring the solution to the required strength. Theoretically, there would be required 70 lb. of soda ash, which checks near enough. Thereafter compound is pumped in, as indicated by the tests, to compensate for the alkali lost or neutralized by the blowoff, condenser leakage, makeup water, etc.

This method of treatment was started in 1914 and has continued without interruption to date. Steaming or idle the boilers have contained 2½ per cent normal alkalinity or stronger for 12 years. Previous to 1914 some very serious corrosion occurred in the boiler drums, the reason for starting the treatment. In 1919 it was decided to renew some of the corroded plates. The plates removed were tested and found to comply fully with the requirements for new boiler plates. Nothing resembling cracking or embrittlement ever has been observed.

Concentration of sulphate is not known, nor can it be estimated from the above figures because the quantity of blowoff and the character of makeup is not known.

Mare Island Navy Yard

The following information relative to the use of boiler compound in the Navy is extracted from a letter received from C. S. McDowell, Captain, U.S. Navy, Engineer Officer, Navy Yard, Mare Island:

Use of the compound should be so regulated that the boiler water is kept between the limits of 0.1 and 0.5 per cent normal alkaline strength. Careful compliance with this rule will prevent any but slight general corrosion of boilers.

Water should be tested daily for alkalinity and chlorinity in steaming boilers; weekly in idle boilers.

Boiler compound should not be put into a boiler in bulk, but should be introduced through an external and gradual source such as a connection on a feed pump.

When the use of boiler compound was in its infancy, the limits of use prescribed were those that kept the boiler water between 3 and 4 per cent normal alkaline solution, at which strength corrosion and scale were practically prevented. However, such limits were found to be impracticable in marine use, due to: (a) danger of the strength falling under 3 per cent, at points lower than which corrosion is very active; and (b) danger of priming in small-tube boilers with water at this strength. Hence the present limits between 0.1 and 0.5 per cent, were established because it was recognized that only a slight general corrosion can obtain with water treated with compound to bring it within these limits, and that danger of priming due to compound is practically nil.

No trouble relative to caustic embrittlement of metals has been encountered through use of the compound within its present prescribed limits.

Navy Compound: 1.—The compound shall show on analysis at least 76 per cent of anhydrous sodium carbonate (NA_2CO_3), 10 per cent of trisodium phosphate ($NA_3PO_412H_20$), 1 per cent of starch and sufficient cutch or dry extract of hemlock, oak or chestnut bark to yield 2 per cent of tannic acid. Dry extract of quebracho will not be accepted as a substitute source of tannic acid. The remainder shall consist of water and only such impurities as are common to the ingredients.

This company has been investigating some trouble experienced with leakage in the longitudinal joint of the seam drum of one of the 1,166-hp. boilers that has been in service for about four years. Some rivets were removed from the drum and several cracks were found in the sheet at the rivet holes. A new drum is being installed. Further investigation will be made when butt straps are removed from the defective drum.

Great Western Power Company

A hot-water lime-and-soda process is installed in a boiler plant which uses water from the city mains and generates steam for a district steam-heating system. None of the water returns to the plant. Raw water is heated to 195 deg. and more in an open-type feed heater of usual design which was in place before the softener was installed. The water level of the heater is 16 ft. above the floor. A motor-driven centrifugal pump set on the floor draws the hot water from the heater and delivers it to the chemical proportioning tank of the softener, 30 ft. above the floor. The softener tank is 8 ft. in diameter and 16 ft. high, set on a frame 8 ft. high to make room for the pressure-type sand filter under the softener tank.

Rated capacity of the softener is 90 gal. per min. Making a suitable deduction for unfilled space at the top and for sludge space at the bottom, the water remains in the softener tank 50 min. at this rating. To date the softener has not been operated above 70 per cent of its rating. It should be noted that the hot water passes through the chemical proportioning device. The result is a deposit of light scale which cracks off and obstructs the orifices unless the device is cleaned periodically. A better arrangement would be one in which the cold raw water operates the proportioning device. The softener has been in operation for a year. So far no trouble has been experienced from scale in the centrifugal pump or connecting lines.

Water level in the softener tank is from 22 to 23 ft. above the floor. Feed pumps are horizontal duplex steam pumps set on the floor. Their capacity is ample at moderate speed. The 22 or 23-ft. head is sufficient to force the hot water through the sand filter and all pipe connections to the feed pumps, provided that the sand filter is carefully back-washed at proper intervals. The head of water from the softener is insufficient to back-wash the sand filter. Water from the city mains was connected, but the quantity and pressure were prohibitive. The quantity of water required for thorough back-washing is more than at first expected. The filter now is back-washed with compressed air and water. The addition of a back-wash pump using soft water and returning it to the softener was not considered advisable for a plant of this size.

A ¼-in. air pipe with 100-lb. at the compressor is opened wide into the back-wash water pipe and a moderate amount of water from the city mains is turned on. The combined pressure under the sand-bed nozzles is regulated to 30 or 40 lb. The result, viewed through the manhole, resembles a boiling of the sand. This is regarded as important. The filter is back-washed every day at off-peak times until the water comes clear. This requires from 15 to 30 min. at present winter loads. During the back-washing periods the feed pumps draw directly from the softener tank. The water is clear at off-peak times, nearly all sedimentation taking place in the softener tank.

For regulating the charge of lime and soda a sample of softened water is drawn at 2 a.m. and 2 p.m. and tested. There is considerable variation in the character of the raw water. Also the proportioning of the chemicals in the proportioning device is not exactly the same at large and at small rates of flow. A good average of softened water as indicated by the above-mentioned samples is sought. A charge lasts from 30 to 50 hr. depending upon the load. A charge once made is allowed to run through. Aluminum sulphate is added to the charge to the extent of 1 lb. to 4,000 gal. of soft water. The softened water is tested for causticity to phenolphthalein, for alkalinity to methyl orange, and for hardness to soap. All results are expressed in parts of calcium carbonate per 100,000 called degrees. A degree is 58 per cent of a grain per gallon.

Trouble was experienced in obtaining a soap solution which would give consistent results. Now satisfactory results are obtained by buying "standard" soap solution from a chemical supply house. The "standard" solution is made and standardized according to the "standard methods of water analysis" of the American Public Health Association. This publication also contains a table showing a purely arbitrary relation, experimentally determined, between soap and hardness.

The boilers are blown off to keep the salt below 400 deg. This indicates a 10 per cent blow-off. Boiler water contains some sludge from the accumulated hardness of the feed water in addition to the alkali and salt. They will operate at 160 per cent rating, 100-lb. boiler pressure, without foaming. Foaming is indicated by a drop in superheat temperature.

* **Report of sub-committee.—H. S. Markey, chairman.** V. E. Estcourt, E. G. MacDonald, A. Y. Mendell, W. E. Thompson.

Pacific Gas and Electric Company

Cold Process Water Softening.—The North Beach station of the Pacific Gas and Electric Company is equipped with a cold-lime-and-soda process softener This softener has a capacity of 6,000 gal. per hr. and was installed in October, 1918. It is used for treating the raw makeup water.

In the operation of this equipment the procedure is as follows:

The charge of lime and soda first is mixed with water in the mixing tank and then is pumped to the agitator tank where it is agitated continually by compressed air. From the agitator tank the chemicals are fed through an orifice. The head of chemical on this orifice, and thus the flow of chemical through it, is regulated by a balance mechanism which regulates the ratio of chemical-to-water. The water then flows into the softening tank which is divided into two sections so that the treated water flows down to the bottom of the tank on one side and is drawn off at the top on the other side. From here the water flows by gravity to the storage tanks and thence to the hotwell. From the hotwell the water is pumped through a filter to the feedwater heater. Sufficient storage is provided so that about 20 hr. is allowed for the reaction to run to completion.

Water from the softening tank, the storage tanks, the feed water, and the water in all boilers under pressure is tested daily. Boiler water from standby boilers is tested twice a week and city water is tested once a week. Tests are made for hardness, causticity, alkalinity and chlorinity. Table I shows average results.

TABLE I—Feedwater tests.

	Softening Tank	Feed Water
Hardness (Fr. deg.)	5	1
Causticity (Pts. per 100,000)	5	1
Alkalinity (Pts. per 100,000)	9	2

Condenser Leakage.—Condensate is tested hourly for chlorine, which is kept below one gr. per gal. If this amount is exceeded, sawdust is admitted into the circulating water and this generally stops the small condenser leaks. If the sawdust fails and the load is light the condensate is dumped into the sewer. If the load is heavy the condensate is not dumped, but soda ash is added directly to the hotwell.

Results Obtained.—This method of treating the water has proved to be satisfactory. During the years 1920 to 1925 the lower six rows of tubes in each boiler were the only tubes cleaned. In 1925 all tubes were cleaned because of the severe operating conditions during 1924. During the present year only a few scattered tubes have been cleaned. Most of the tubes show absolutely no hard scale and only an extremely thin film of very soft scale.

Table II shows certain physical data in connection with the boilers, and Table III shows the number of tube renewals in the year 1918. Unfortunately no accurate records are available previous to that year.

TABLE II—Physical data for boilers at North Beach plant of the Pacific Gas and Electric Company, San Francisco.

No. of Boilers	Make	Date Installed	Total Rated H. P.	Tubes Wide	Tubes High	Tubes per Boiler	Total Tubes
8	B&W	1902	4,000	21	12	252	2,016
6	B&W	1907	3,600	21	14	294	1,764
2	B&W	1914	1,200	21	14	294	588
2	B&W	1914	1,400	24	14	336	672
Total: 18 Boilers			10,200				5,040

Interpretation of Analysis Made by Titration Method.—Customary routine method for testing the alkalinity of samples of treated water is by titrating the sample with a solution of sulphuric acid, using phenolphthalein and methyl as indicators. Hardness is obtained by using a standard soap solution. The general method of conducting these tests is so well known that it will be unnecessary to take up space with a description.

The units in which results are obtained depend, of course, upon the volume of the sample tested and the strength of the sulphuric acid used in the titration. Most water-softening companies supply a testing outfit with the water softener when installed, with instruction to use a certain volume of sample and a certan strength of acid. Further instructions are given as to the relationship to be maintained between the hardness, causticity and alkalinity for properly treated water.

Sometimes it is desirable, however, to be able to calculate the actual amount of bicarbonates, carbonates and hydroxides in the water from the results of the titration.

In making a comparative study of different methods of water-softening in use at various stations, it also is of value to be able to interpret the results at one station in terms of the results obtained at another station. This, of course, may be done by using well known conversion factors, provided it is known in what units the results of titration are given. Sometimes it happens that these units are not known, the operator relying entirely upon maintaining a given relationship between the various readings, according to the manufacturers' instructions. In such cases, in order to make any comparisons with readings obtained at other stations, it must be know how to determine and in what units the results of a titration test are given when various strengths of acid and various sized samples are used.

TABLE III—Tube renewals at North Beach plant of the Pacific Gas and Electric Company, San Francisco.

Year	Tubes Renewed	Station Load Factor	Remarks
1918	516	0.36	Water softener inst. Oct. '18.
1919	77	0.42	
1920	457	0.49	All boilers thoroughly overhauled and all weak looking tubes replaced.
1921	212	0.23	
1922	87	0.27	
1923	50	0.31	
1924	263	0.68	
1925	62	0.14	
1926	45	0.05	5 tubes replaced in lower three rows. The other 40 tubes gave out at headers.

The following data are offered as the simplest method of calculating the actual quantities of alkaline solids in the water and also of determining in what units the results of a titration analysis are given if the strength of sulphuric acid and the size of the sample are known.

These tests are based upon the following characteristics of phenolphthalein and methyl orange when they are used as indicators.

When only bicarbonate (HCO_2) ions are present, phenolphthalein remains colorless when H_2SO_4 is added If methyl orange is added the color of the solution will remain yellow until the bicarbonate is neutralized with H_2SO_4, at which point the orange color of methyl orange appears.

When only carbonate (CO_3) ions are present, phenolphthalein will indicate the end-point when only half the acid required to reach the end-point with methyl orange is used.

When only hydroxyl (HO) ions are present, both phenolphthalein and methyl orange will indicate the end-point after exactly the same amount of acid has been added.

From the above facts Table IV may be obtained.

TABLE IV—Actual amount of alkaline substances present for various values of "P" and "M" when water is titrated with sulphuric acid.

Condition	Amount of Alkaline Ions Present HCO_3	CO_3	OH
P = O	M	O	O
2P—M = less than O	M—2P	2P	O
2P—M = O	O	2P	O
2P—M = more than O	O	2(M—P)	2P—M
P—M = more than O	O	O	M

In Table IV:

P = c.c. sulphuric acid required to reach end-point when phenolphthalein is used as indicator.

M = c.c. sulphuric acid required to reach end-point when methyl orange is used as indicator.

F = normality factor.

K = dilution factor.

then, $K = 20 \times F \times$ c.c. of sample.

Example

100 c.c. sample taken,

$\frac{N}{50}$ sulphuric acid used.

then $F = 50$ and

$K = 20 \times 50 \times 100 = 100{,}000$

This means that for a 100-c.c. sample and $\frac{N}{50}$ sulphuric acid the values of P and M in Table IV will be in "parts per 100,000."

Southern California Edison Company Long Beach Steam Plant

Makeup water required by the Long Beach steam plant No. 2 of the Southern California Edison Company is supplied entirely by evaporators. The quality of the raw water supply is much above the average as far as hardness is concerned, and in a great many smaller installations would be considered a satisfactory feed water without any treatment whatever. A representative analysis is as follows:

Sodium carbonate	4.77	Magnesium carbonate	1.59
Sodium chloride	5.5	Iron and alumina	0.45
Sodium sulphate	3.35	Silica	0.44
Calcium carbonate	4.12	(All values in gr. per gal.)	

It may be noted that the water carries appreciable sodium carbonate or soda ash which mounts up to a high value in the boiler shell. According to the latest theories, a part of this carbonate breaks up at high temperatures forming sodium hydroxide or caustic soda, and the resulting mixture, if not under proper control, contributes heavily towards caustic embrittlement. Also, the calcium and magnesium carbonates are responsible for much scale which, however, is of a soft variety and easily removed. This water would lend itself readily to treatment by a number of different methods among which the hot lime-and-soda process would be the choice, or a Zeolite process supplemented with an acid treatment to reduce the alkalinity.

Regardless of the method of treatment used, the feed water always would carry impurities which would form some scale and require excessive blowdown when used in boilers subjected to the ratings of the boilers in this plant. For these reasons evaporators were installed. The result is that as long as the water is not contaminated by condenser leakage or raw water scale accumulations are very small and blowdowns practically unknown. Boilers have been known to operate from 2,000 to 2,500 hr. without cleaning and blowdowns very seldom come under 1,000 hr. and even then not frequently. The formation of scale and the necessity of blowing in that way was shifted from the boiler room to the evaporators. This, however, was considered a good trade because the evaporators could be removed from service without disturbing operation, and the danger of tube failures had been lost in the change. Heat loss from blowdown still was present and practically as great for the reason that the low heat content of evaporator water is offset by the necessity of dumping or blowing more often to prevent priming at the lower pressure.

Accumulation of scale in the evaporator, however, proved to be a bigger problem than was expected. The scale, being of a soft variety, did not lend itself readily to cracking, which is the accepted method of cleaning evaporators. It was found necessary to remove the coils and clean them by hand. This entailed much labor and caused excessive wear on the soft copper tubes. Later, a solution of muriatic acid was used, circulated by a pump until the scale was dissolved. This method did good work, but there was present the chance of contamination by acid and the corrosive action of the acid on the metal parts of the evaporator.

Finally it was decided to install a Zeolite softener when the addition to No. 2 plant was built. This process changes all scale-forming calcium and magnesium compounds into soluble sodium compounds. A representative analysis of the softened water is as follows:

Sodium carbonate	0.2	gr. per gal.
Sodium bicarbonate	18.9	gr. per gal.
Sodium chloride	6.0	gr. per gal.
Sodium sulphate	2.93	gr. per gal.
Calcium carbonate	0.4	gr. per gal.
Silica	1.65	gr. per gal.

Immediately after this water was put into use all the scale accumulations peeled off the evaporator coils, and no scale has formed since. The high alkalinity makes it necessary to blowdown often to prevent priming but gives no other worry.

As a matter of fact the company is convinced that the presence of this high alkalinity and the tendency of the evaporators to prime is of actual value for this reason: wherever sea-water is used for condensing purposes there is danger of contamination of condensate which, upon arrival at the boiler, sets in to tear down whatever alkalinity there may be and then causes corrosion and contributes heavily toward scale formations. Of course no condenser is absolutely tight and always a trace of sea-water is present in the condensate. The distilled water normally carries enough free soda, which is the effect of priming, to neutralize the sea-water and to keep the boiler water slightly alkaline. At times when condenser leakage has increased, the alkalinity in the boilers very nearly has been destroyed, but never yet have the boilers shown an acid reaction. In case of too close an approach to the acid state it would be necessary to introduce either soda ash or trisodium phosphate to bring the alkalinity back to safe values.

It has been suggested that the concentration in the evaporators might be regulated so that the evaporators will prime just enough to neutralize the condenser leakage. This procedure might prove practical under normal conditions or as a relief until the condenser could be repaired. It never should be used as a substitute for condenser repair because, regardless of how good the conditions in a boiler room may be, as soon as the feed water becomes contaminated by even a relatively small amount boiler blowdowns, priming, tube failures, boiler cleaning and all those boiler-room ghosts, considered as gone forever, again will enter at the front door and take charge of the plant.

Los Angeles Gas & Electric Corporation

Makeup water for the Alameda Street station of the Los Angeles Gas & Electric Corporation is supplied from the city mains of the water department of the City of Los Angeles. This city water contains 12.74 gr. per gal. of incrusting solids which it is necessary to remove. Clarifiers or sand filters are installed with Zeolite softeners. The clarifiers were installed to remove suspended matter that would cause the Zeolite bed to choke up and lessen its effectiveness.

Before the present system of evaporators was installed for furnishing makeup water to the south boiler house the soft water was used for makeup. Boiler conditions were very good and so long as concentration remained below 3 parts per 1,000 of sodium chloride, no foaming was experienced at normal boiler ratings. An electric concentration instrument which shows the concentration of the boiler in parts per thousand NaCL was installed and the concentration reduced as necessary by blowing the boilers.

It may be interesting to note here that after evaporators were installed the makeup water was furnished direct from the city mains, but so much scale formed in the evaporators that their ouput was reduced greatly. At present soft water is supplied to the evaporators, eliminating the necessity of taking them out of service for cleaning. The soft water is used primarily for makeup in the cooling towers. Since the soft water has been used for makeup in the towers, condenser tubes require no cleaning, and the scale-forming materials have been eliminated.

There is no trouble with foaming when running boilers at normal rating, but there was some foaming when running at 150 per cent rating and up. To overcome this evaporated water is used entirely for makeup. The plant is equipped with two sets of Wheeler double-effect film evaporators operated on exhaust steam, each of a capacity of 15,000 lb. of distilled water per hour.

There is a horizontal clarifying filter, used with each unit of two water softeners, 8 ft. in diameter by 25 ft. long, and containing a filter bed consisting of four layers of crushed gravel and sand ranging from the finer material on top to the coarser material at the bottom. It is fitted with a double-section-type washing system so that half the bed may be washed at one time. This equipment will filter water at the rate of 500 gal. per min. and is built for a pressure of 50 lb.

The two water softeners each are 9 ft. inside diameter by 23 ft. 1 in. long, constructed of steel to withstand 50-lb. pressure, and fitted with meters, valves and piping necessary to operate. Each softener will soften 600,000 gal. per 24-hr. period at the rate of 25,000 gal. per hr. The softened water will not contain any lime or magnesia when tested by the soap test, and not more than 1.4 c.c. of soap solution will be required to form a permanent lather in 100 c.c. of softened water. The softened water, when used for boiler feed, will not deposit scale, sludge or mud in boiler connections, thereby eliminating the necessity of taking out boilers for cleaning.

The clamation tank consists of one wooden salt-solution tank of 8,000 (U.S.) gal. capacity, one wooden salt-measuring tank of 2,400 (U.S.) gal. capacity, and one motor-driven brine pump.

The softener is re-generated by running a salt brine of from 12 to 15 deg. Beaumé slowly through the Zeolite for 6 hr.

Tables V and VI show results of analyses of raw water and of softened water.

TABLE V—Industrial analysis city water—Palmetto Street—Alameda Street station.

Analysis of Solids	Grains per U. S. Gallon	Incrusting Solids	Grains per U. S. Gallon
Suspended matter	None	Suspended Matter	None
Silica (SiO)	1.31	Silica	1.31
Iron oxide and alumina R_2O_3	0.18	Iron oxide and alumina	0.18
Lime (CaO)	5.24	Calcium carbonate	8.19
Magnesia (MgO)	2.40	Calcium sulphate	1.58
Soda (Na_2O)	2.50	Calcium chloride*	None
Sulphuric anhydride (SO_3)	4.76	Magnesium carbonate	1.48
Chlorine (Cl)	1.93	Magnesium chloride*	None
Carbon dioxide, combined (CO_2)	4.58	Total	12.74
Volatile and organic matter	2.22	Non-Incrusting Solids	
Total	25.12	Sodium carbonate	0.50
Excess oxygen	.44	Magnesium sulphate*	5.04
Total solids	24.68	Sodium sulphate	1.00
Hydrogen sulphide (H_2S)	None	Sodium chloride	3.18
Carbon dioxide, half-bound	4.58	Volatile and organic matter	2.22
Carbon dioxide, uncombined	None	Total	11.94

*Forms some scale in presence of calcium carbonate and sodium carbonate.

TABLE VI—Industrial analysis soft water, north evaporator inlet.

Analysis of Solids	Gr. per U. S. Gal.	Incrusting Solids	Gr. per U. S. Gal.
Suspended matter	None	Suspended Matter	None
Silica (SiO_2)	1.26	Silica	1.26
Iron oxide and alumina (R_2O_3)	0.21	Iron oxide and alumina	0.21
Lime (CaO)	0.13	Calcium carbonate	None
Magnesia (MgO)	0.20	Calcium sulphate	0.31
Soda (Na_2O)	11.88	Calcium chloride*	None
Sulphuric anhydride (SO_3)	4.84	Magnesium carbonate	0.15
Chlorine (Cl)	2.05	Magnesium chloride*	None
Carbon dioxide, combined (CO_2)	4.82	Total	1.93
Volatile and organic matter	0.58	Non-incrusting solids	
Total	25.97	Sodium carbonate	11.41
Excess oxygen	0.47	Magnesium sulphate*	0.39
Total solids	25.50	Sodium sulphate	7.81
Hydrogen sulphate (H_2S)	None	Sodium chloride	3.38
Carbon dioxide, half-bound	4.82	Volatile and organic matter	.58
Carbon dioxide, uncombined	None	Total	23.57

*Forms some scale in presence of calcium carbonate and sodium carbonate.

San Joaquin Light & Power Corporation

At the Bakersfield and Midway steam plants the water supply is derived from wells situated on the company's property at the plants. This water runs from 3 to 5 gr. per (U.S.) gal. of incrusting solids. At normal operations the makeup water amounts, at maximum, to 6 per cent of the total boiler feed.

This water is heated in open feed-water heaters with the condensate very near to the boiling point. Carbonate constituents largely are eliminated during this process. Feed water to the boilers runs at an average of 0.4 gr. hardness. Boiler compound of a soda base is introduced into the boiler feed lines to maintain an alkaline condition in the boiler water. The compound, although not eliminating scale within the boilers, has kept the scale in a softened condition which facilitates its removal.

Spray ponds and cooling towers are in use at the Midway steam plant. The water which supplies these ponds is from the same source as that used for boiler makeup water. During the summer months the great evaporation from these ponds results in water in them becoming concentrated. Hardness will run as high as 15 or 16 gr. with a corresponding increase in sodium chloride. This water has and would prove detrimental to the boilers due to condenser leakage. Therefore a close check is kept on the condensate for indications of leakage which, when developed, is remedied promptly.

Boilers are taken out of service for cleaning once a year.

Burning of Liquid and Gaseous Fuels*

This report contains the views of three member companies on the following subjects:

1. Water-cooled walls and their effect upon the combustion of oil and gas.
2. Air preheaters and their effect upon the combustion of oil and gas.
3. Comparison, from an operating standpoint, of two different oil and gas burners.
4. The prevention of pulsation in the operation of mechanical atomizing burners under natural draft.

Water Cooled Walls and Air Preheaters

One company has two 890-hp. Stirling boilers set in battery, one equipped with water-cooled side walls and the other with air-cooled walls. Both boilers burn oil only. The water-cooled surface consists of a bank of twelve 3¼-in. o.d. tubes on the side and battery walls, and inclined at an angle of approximately 15 deg. from horizontal. These two banks of tubes are rolled into two sets of front and back headers. The back headers are connected to the mud drum and the front headers to the front steam drum. This additional surface adds about 60 boiler hp. per side, increasing the total boiler hp. from 890 to 1,010 bhp. No refractory covering is used on the tubes, their entire surface being exposed.

The most noticeable effect was the reduction in furnace temperature of from 350 to 450 deg. F., depending upon the load as shown in Fig. 1. The maximum obtainable CO_2 without excessive smoke was approximately 12.0 per cent. This was slightly lower than could be obtained in the boiler without water-cooled walls, but no accurate data yet has been obtained relative to the comparative efficiency with and without water-cooled walls. However, a portion of this temperature difference must be attributed to the difference in percentage of CO_2 in the two boilers.

The boiler has been examined twice since the water-cooled walls were installed and the tubes were found to have a deposit of scale a little more than 1/64-in. thick on the side of the tube nearest the flame. Brickwork is in good condition, but the boiler has not been in operation long enough to state whether there is any appreciable reduction in furnace maintenance.

Another company has boilers equipped with air preheaters and with water-cooled side walls and part of the front wall. Inasmuch as the boilers always are operated with preheated air the discussion refers to the effect of the combination of water-cooled walls and air preheaters upon the combustion of oil and gas. The water-cooled wall seeks to replace the solid refractory wall with an arrangement which will dissipate the heat received by radiation at a rate sufficient to prevent destructive temperatures, and at the same time retain that property which is accepted generally as being so necessary in a boiler furnace, namely, a radiant surface.

That part of the furnace which is to be cooled is lined first with vertical tubes the tops and bottoms of which are expanded either into special headers or into the boiler drums. If expanded into special headers the headers are connected to the boiler proper in a manner that will allow circulation of the boiler water through the walls. Sometimes water is admitted to the walls only as fast as it is evaporated and the walls themselves recirculate and discharge only the steam to the boiler. Great care is necessary in erecting to keep the tubes in perfect alignment. The tubes next are cleaned on the outside and polished with emery cloth and then special blocks are affixed to them. These blocks are cast iron and faced with a special refractory. In their manufacture the cast iron is poured around the refractory and anchoring lugs pass entirely through. The blocks are formed to fit between two adjacent tubes, bearing upon about one-fourth the circumference of each. The block is held in place by a central stud and a strong-back on the back of the tubes. In attaching the blocks a special bonding cement is used between block and tube to fill up any irregularities in the surfaces and which is said to make an efficient and permanent bond. When completed, the wall presents a solid refractory surface to the fire. This refractory is only about 1¼ in. thick, giving a very steep temperature gradient.

The actual effect of these walls upon combustion is hard to determine for the reason that the had effect of lower furnace temperature is overbalanced by the good effect of preheated air. The effect of the walls

* Report of sub-committee.—C. H. Delaney, chairman. F. T. Ellis, H. T. Woodward, C. H. Zeise.

upon furnace temperature, however, is obtained easily. For determining temperatures in a furnace an optical pyrometer usually is used. In the use of such an instrument care must be taken so that successive readings will be comparable. When burning oil the temperature of the refractory on the bridgewall, sidewall, frontwall and floor all are different with the flame tempera-

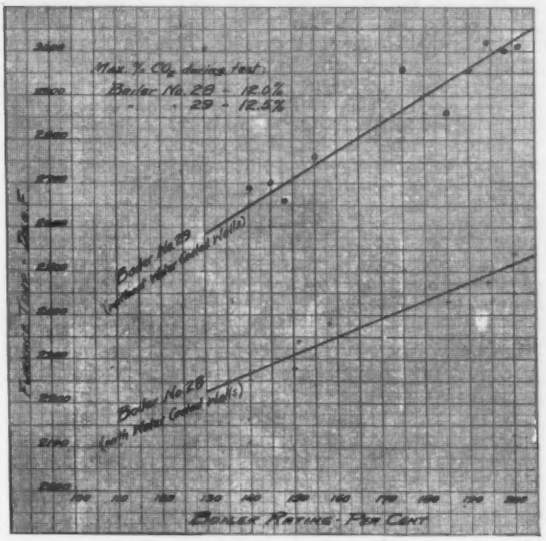

Fig. 1. Curves showing the effect of water-cooled walls upon furnace temperatures, boilers 28 and 29, Station A, Pacific Gas and Electric Company, San Francisco.

ture much higher than any of them. The same is true to some extent in a gas-fired furnace except that there is no flame and that refractory temperatures are all that are obtainable. For that reason any temperatures in this discussion should not be considered as average furnace temperatures, but rather refractory temperatures with same or similar locations and conditions.

In the first unit of No. 2 plant, where air-cooled walls are used, it is not uncommon to observe temperatures of refractory at the rear of the furnace as high as 3,100 deg. F. when operating a boiler at 300 per cent rating with oil and using approximately 5 per cent excess air. This value will drop below 2,900 deg. as air is increased to 20 per cent excess. In the addition to No. 2 plant, where water-cooled walls are used, with a boiler operating under the same conditions the maximum temperature of a section of uncooled refractory wall at the rear of the furnace is only 2,700 deg. F., dropping off to 2,400 deg. as excess air is increased to 20 per cent. The water-cooled walls themselves, when first installed, were about 200 deg. lower than the uncooled refractory. However, during the several months of operation the front face of the refractory has loosened up to a depth of about ½ in. from the surface and this loose face no longer has good contact with the cooling wall. The result is that the temperature of these blocks is very close to the temperature of the uncooled refractory. These front faces gradually are dropping off and the sections thus uncovered are from 250 to 300 deg. cooler than those sections still holding in place. As these faces drop off, the average temperature naturally will drop. Just where it will stop still is a matter of conjecture.

The lowered furnace temperature, with cold or slightly heated air, would be sure to have the effect of delaying combustion, producing long flame travel and probably make necessary the use of high excess air. This effect is prevented by use of moderately preheated air. An economizer is used between the boiler and preheater that has the effect of reducing the quantity of heat in the stack gases and limiting the temperature to which air can be preheated. In this case the temperature of air at 300-per-cent rating is about 300 deg. F. Even at that temperature the hot air has the effect of entirely off-setting the effect of the cool walls. The combustion rate is better and length of flame much shorter than with the air-cooled setting when furnace temperatures are high and air temperatures are about 150 deg. F. Without economizers and with all of the heat given off from the boiler available for preheating air, temperature from 450 to 550 deg. F. and even higher would be possible. With such temperatures, more water-cooled surface could be used in the furnace.

This effect of accelerating combustion with hot air probably is not due to temperature alone. As temperature increases, volume also increases, which in turn increases the velocity through the air register. This increase in velocity produces greater turbulence and better mixing of air and fuel, which alone is an aid to combustion.

The cold furnace will have a greater retarding effect when picking up load because it is only when thoroughly hot that the water-cooled walls will glow. Also, air temperature is low under starting conditions. In a quick pick-up from a cold condition the air-cooled furnace is the quicker of the two. Inspection of the furnace shows that the water-cooled sections remain dark-long after the uncooled sections are bright red. When cooling down the water-cooled section is black within a few seconds after the fires are cut out.

When burning gas the presence or absence of water-cooled walls or preheated air really is of very little importance. When burning gas alone the highest temperatures possible in a furnace would not injure a refractory sufficient to justify water cooling. On the other hand it is improbable that, when gas is burned in combination with other fuels, any cooling used for the other fuel would give too low a furnace temperature for proper combustion of gas. Combustion of gas is accelerated, of course, with increase in furnace temperature and air temperature, but not to the extent that oil is.

In an air-cooled furnace operated at 300-per-cent rating on gas with 5 per cent excess air, temperatures range from 2,750 to 2,800 deg. F. In the water-cooled furnace an uncooled section of refractory will not attain a temperature above 2,400 deg. and the water-cooled section will be below 2,200 deg. No difference can be noticed between the gas fires in the two types of settings other than the furnace temperature.

Operating Comparison of Two Combination Burners

In general arrangement these two burners are quite similar, but in details are somewhat different. Each one consists of the following major items: a firing arch, an air register, a gas burner and an oil burner. The firing arch is circular in shape and is built into the furnace wall. A section through this wall would show the general shape of a Venturi tube. This Venturi tube in burner A is 16⅜ in. in diameter at the throat and 9 in. long, the 4½-in. length closest to the fire being composed of refractory and the remaining 4½ in. length of cast iron. This cast-iron portion of the tube contains 10 blades set radially and at an angle of about 30 deg. with a center line through the tube. These blades extend about 3 in. into the throat and their purpose is to impart a spinning motion to the air. The Venturi tube in burner B is about 18 in. long, 15 in. in diameter at the throat and perfectly smooth inside. The 9-in. length nearest the fire is composed of refractory, the next 4 in. is formed by the gas burner and the remaining length by a casting affixed to the air register. The air register in burner A is cylindrical in shape and projects outward from the firing arch. The walls are formed by the register blades which open inward, swinging from one edge. The air register in burner B takes the shape of a frustum of a cone with the base affixed to the firing arch. The sides are formed by the blades which pivot about their center. The position of these blades is controlled from the outside by a lever or knot. The end of the register away from the fire is closed by a cast-iron front plate equipped with operating lever and peep-holes. When firing oil, the oil burner is inserted through an opening in the center of this front plate and reaches as far as the throat of the firing arch from which it throws a conical spray of oil into the furnace.

To make changing of burners easy a hollow pipe is placed permanently in this position and through this pipe, or distance piece, the oil burner is inserted. This distance piece is so arranged that it may be slid forward or backward at will. The outer end of this distance piece carries half of a quick-detachable coupling the other half of which is affixed to the oil burner. A flexible hose completes the connection from the fitting on the distance piece to the oil header. A dish-shaped casting about two-thirds the diameter of the burner

throat is used on the inner end of the distance piece just back of the oil spray to protect the spray from the action of the air until it gets far out into the burner throat. These impeller plates or diffusers are of different designs and are made from special heat-resisting metal.

The gas burner B, as indicated, is rigidly fixed as a part of the firing arch. The openings through which the gas is admitted extend entirely around the arch and the gas is injected toward the center of the arch in a conical shape. The burner is connected to the gas header by means of standard pipe. In the last installation all this piping, except the operating valves, is concealed inside the windbox. In burner A a special arrangement is used for a distance piece, composed of two concentric pipes on the inner end of which is mounted the gas burner head and on the outer end a special fitting which closes off the end of the outside tube and surrounds the inner tube leaving the inside of the inner tube available for the oil burner. As this assembly must be slid in and out at times, it is connected to the gas header by means of a large flexible hose. The gas burner head delivers gas through a series of holes which inject it in a conical shape outward into the air stream. When firing gas the impeller plate is pulled back out of the way. Because of the exposed position it is necessary to make these burner heads from heat-resisting metal.

For the reason that gas is admitted from the center and the whirling air seeks the outside of the throat, burner A requires a relatively high gas pressure to obtain proper mixing of air and gas. A great deal of experimenting was necessary before a head design was developed which would give the desired results and stand up to the extreme temperature conditions. Even this burner is satisfactory only within a certain range which lies between 200 and 300-per-cent boiler rating. Above or below this range poor mixing with visable flame and secondary combustion make this design impractical. As before stated, the burner head is made from heat-resisting material and gives no trouble even with oil fires, but the inner tube, composing the distance piece which is expanded into the gas burner, burns out in a very short time. A replacement of these parts is necessary every few months. It has not been considered practicable to date to make them from special material.

Burner B admits gas from the outside of the throat in the position in which the spinning air tends to travel. For this reason very little pressure is necessary. These burners will operate satisfactorily at practically any rating and as much as 25,000 cu.ft. of gas per hr. per burner may be handled successfully. This would be equivalent to more than 600-per-cent rating on the boilers. Some difficulty was experienced with the first burners due to warping and cracking of the gas boxes. It was necessary to rebuild them to correct the warping. Some of them were fitted with detachable plates, which make repairs easy in case of cracking. The newer burners are built in that way.

Results when firing with oil are not much different and in fact should be no different, as the methods of spraying the oil and admitting the air are fundamentally the same. Oil firing, however, requires much closer adjustment to get satisfactory furnace conditions with burner A than with burner B. By unsatisfactory furnace conditions is meant impingement of flame upon bridgewall or tubes or the necessity of using excess air to prevent this impingement. This difference may be due to the smaller throat diameter and correspondingly higher air velocity in burner B, or, the turbulent effect might be greater. Just at present there is considerable difficulty in burning up diffuser plates on the burners of this type and some experimenting is being done with different positions and designs.

In making a change of fuels burner B is much superior to burner A as far as speed and accessibility is concerned. For instance, when burning gas and a change to oil is expected, burner B may be inserted into the distance piece and clamped in position leaving the assembly pulled back out of range of the fire. When the change comes, the burner needs only to be pushed forward and the valve opened. With burner A the distance piece must be left pushed forward because it carries the gas burner which is in service. While in that position an oil burner surely would be damaged if inserted and clamped in place before turning on the oil. Likewise when changing from oil to gas the burner must be removed as soon as possible after the oil is turned off, while burner B may be shut off and pulled back out of the fire until time is available to remove it. When a number of boilers are to be changed over quickly this feature is a distinct advantage.

For burners of high capacity burner B has what is called a wide-range feature. In using it the maximum amount of oil is furnished to the burner at all ratings. It all passes into the tip and spins at a constant velocity. After spinning, a portion of the oil is bled off and returned to the service tank or pump suction. The amount of oil sprayed into the furnace varies with the back-pressure on the return line. The operator controls his fires by varying this back pressure. The advantage of this arrangement over the straight system is the ability to change from very low to very high capacities with the same set of tips and yet maintain the same standard of atomization at all ratings. The straight oil burner and especially the larger sizes fail to atomize properly at low pressures. When facing a hot furnace they sometimes do not pass enough oil to cool the tips properly and as a result carbonization takes place. Under these conditions some burners usually are cut out so that a higher rating may be carried on those remaining. This practice has the disadvantage that considerable unused air is almost certain to leak in through the unused burners preventing good combustion results. This effect is worse as burner capacities and air pressures increase.

At the plant in question the wide-range feature has not been used. All of the burners are low in capacity (maximum of 700 lb. per hr.) and in such sizes the advantage of this feature is slight. Moreover, the load as a rule is very steady, and not considered fluctuating enough to justify the additional expense of this feature.

Prevention of Pulsation

One company reports that on 1,000 hp. Stirling boilers with integral economizers and San Diego-type mechanical burners it is impossible to obtain a boiler rating higher than 150 per cent without running into violent pulsations. After lengthy experiments it was found that relief could be obtained only by equipping boilers temporarily with induced (steam) draft installed in the base of the stacks. Steam from the main steam headers at 250 lb. pressure and 150 deg. F. superheat is used for this purpose. While this method is costly it became necessary, particularly since the station in question is in standby service and expected to pick up loads without notice. Proper fans will be installed in due time. By maintaining a stack draft of from 1.6 to 1.8 in. with a draft in the furnace of from 1.0 to 1.4 in., pulsations were eliminated at ratings up to 250 per cent. At another station using 2,500-hp. B & W cross-drum-type boilers and equipped with air preheaters, air-cooled walls, forced draft and Peabody-Fisher combination gas-and-oil burners, pulsation is entirely unknown.

Another company reports that after installing water-cooled walls in one boiler it was noticed that pulsations were produced much more readily than before the walls were put in. However, by making certain changes in the sprayer plate (burner orifice) arrangement this trouble was overcome so that pulsations were no worse because of the water-cooled walls. The furnace of the boiler in question is equipped with nine burners, four in the upper row and five in the lower row. Before the water-cooled walls were installed it was necessary to use smaller orifices in the two wing burners of the lower row than in the other burners. After the installation of water-cooled walls it was necessary to eliminate these two wing burners entirely and use larger orifices in the other burners to make up for their loss. With that arrangement the same boiler rating could be obtained with approximately the same fuel-oil pressure and the pulsations were no worse than before the water-cooled walls were installed. The amount of smoke at maximum ratings also was reduced considerably, which would seem to indicate that combustion had not been good because of the two wing-burner flames impinging upon the water-cooled surface.

Regarding pulsations in general, it appears that they nearly always are due to incomplete combustion either in a localized zone or in the furnace as a whole. This in turn may be caused by:

1. Flame impingement upon a relatively cold surface,
2. Poor atomization,
3. Improper distribution of air introduced into the furnace,
4. A general shortage of air for combustion.

Pulsations usually do not occur from causes 1, 2 or 3 unless the quantity of excess air is reduced to a point near the minimum possible without smoke. Conditions in the furnace then are critical as to pulsations and any irregularity produced by any one of these three causes is likely to result in pulsations.

To eliminate pulsations it is necessary to determine which of the above causes is responsible and eliminate it. Improper distribution of air entering the furnace often is caused by using a number of different-sized sprayer plates in the same furnace. In this case the individual air registers on each burner must be regulated according to the relative size of each sprayer plate. Further adjustments also may be made by varying the relative amounts that the burners project into the furnace, by sliding them in or out as required.

Underground Systems Committee Reports[2]

Use of Lead-Covered Cable in Connection with Overhead Transformer Installations*

By H. C. Moyer

Cable Terminals—High Voltage

Many ingenious devices have been placed on the market for terminals of lead-covered cables on poles. Following are some observations made with respect to 3-conductor single-unit-type terminals, and a 1-conductor terminal with voltage rating varying from 600 to 15,000 volts. It has been found that the 3-conductor single-unit-type terminal is not as satisfactory as the 1-conductor type. Trouble has been experienced because of arcing between terminal stems and nuts and because of lightning and fog. The single type is much easier to connect to and disconnect from a line on a cross-arm when the line is hot. Our 3-conductor jobs are being eliminated and the single type installed. Composition

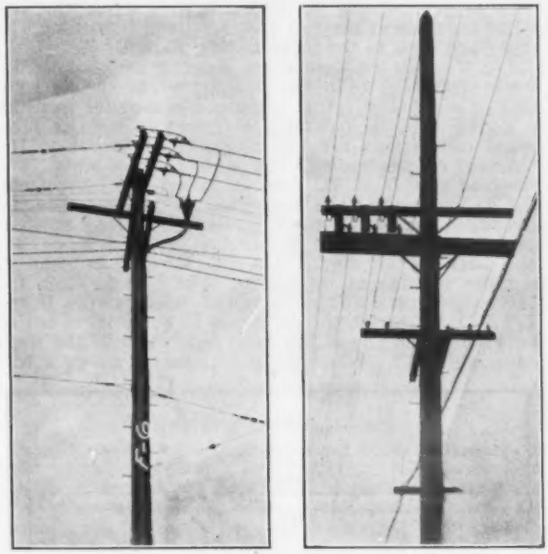

Fig. 1. Single-unit-type, 3-conductor, 4-kv. terminal (left). Single-conductor, single-unit-type terminal (right).

insulators on any cable terminal are not satisfactory and standard porcelain is found to be best.

Thin spun copper and lead bases or bells have been found not to be as satisfactory as cast brass for outdoor terminals. Fused disconnect switches are desirable on primary service taps between cable terminals and line, but are not essential on feeder cables which are tied directly to the line. Aluminum parts are not satisfactory because aluminum deteriorates when exposed to weather. The wiped joint is found to be best for all high-voltage terminals. No need has been found to split to single conductor the indoor terminals which are made in various shapes and sizes.

Joint pole construction brings about many problems none of which cannot be solved by the use of lead-covered cable and cable terminals.

Pole Risers—High Voltage

Extensive experiments have been made in boxing cable on pole risers. At the left in Fig. 1 is shown a 4-kv. riser cable made up with a 3-conductor single-unit-type terminal and boxed only as far as the bend. At the right is shown a 4-kv. riser made up with single-unit terminals and all cable boxed in. At the left in Fig. 2 is shown a 12-kv. riser boxed in as in Fig. 1. More than one riser can be placed safely on one pole, but it is good practice to restrict the number as much as possible.

The use of "F"-type condulets and rubber-insulated

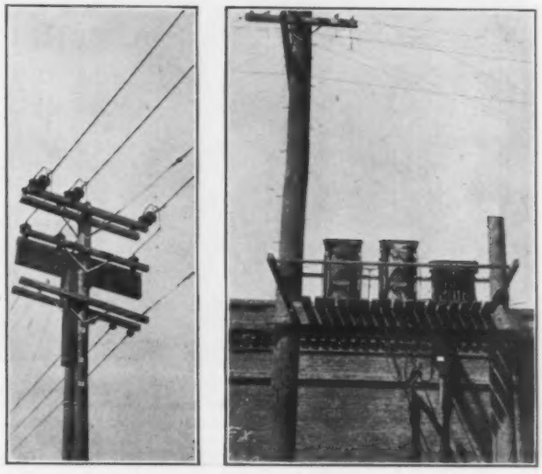

Fig. 2. Cable boxed in on an 11-kv. job (left). Lead-covered primary connection on a pole structure (right).

lead-covered cable has been found desirable on risers carrying voltage lower than 600. The condulet is more simple to take care of on the pole than the filled-type terminal. No difficulty need be experienced with water entering the stranded conductor inside of rubber insulation if proper connection is made to the line. That is, the end of the rubber insulation must point down to shed rain.

Lead-Covered Cable Connections to Overhead-Type Transformers

Lead-covered cable has been used to good advantage on transformers located on pole structures where joint-pole problems arise. This type of installation is shown at the right in Fig. 2, but that view unfortunately does not show the complication which made this plan necessary. In this case it was impossible safely to make open primary drops from our lines through other lines existing on the pole and lead-covered cable was used from our line down the pole and into the transformers with the result shown in the photograph.

Fig. 3 shows three 200-kw. pole type transformers located out-of-doors on a concrete slab; switching devices are located in the building. In this installation, open buses were eliminated and space conserved.

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[2] **N. B. Hinson,** Southern California Edison Company, chairman. **H. H. Buell,** Pacific Gas and Electric Company, vice-chairman. **Coast Valleys Gas & Electric Company:** G. A. Peers. **Glendale Public Service Department:** R. C. Smith. **Great Western Power Company:** G. H. Hagar. **Los Angeles Bureau of Power & Light:** M. O. Bolser, C. H. Jenkins. **Los Angeles Gas & Electric Corporation:** E. R. Northmore, Z. T. Pettit, J. G. Rollow. **Pacific Gas and Electric Company:** P. E. Chapman, R. R. Cowles, G. L. Hill, H. G. Keesling, R. P. Lutzi, H. C. Moyer, P. Suransky. **San Diego Consolidated Gas & Electric Company:** K. B. Ayres, D. J. Kelly. **San Joaquin Light & Power Corporation:** H. H. Minor. **Southern California Edison Company:** C. Biggs, R. B. Guilbault, E. R. Stauffacher. **The Southern Sierras Power Company:** A. C. Putnam. **Standard Underground Cable Company:** Vinton Smith.

* **Report prepared for the underground systems committee.**

Fig 4 shows a bank of four 750-kva. 11/2.3-kv. transformers with lead cable connections on both primary and secondary. The transformers are located in a large vault in the center of a steel rolling mill. Difficulty was experienced on a previous installation, an open-bus pipe-

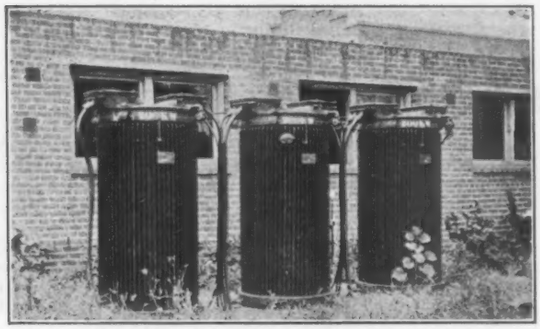


Fig. 3. Lead-covered primary and secondary connections on overhead-type transformers.

frame type, because of the deposit of iron dust on the insulators. Great difficulty was encountered in securing voluntary shutdown of the plant for cleaning, hence insulators continually were causing flashovers. Three

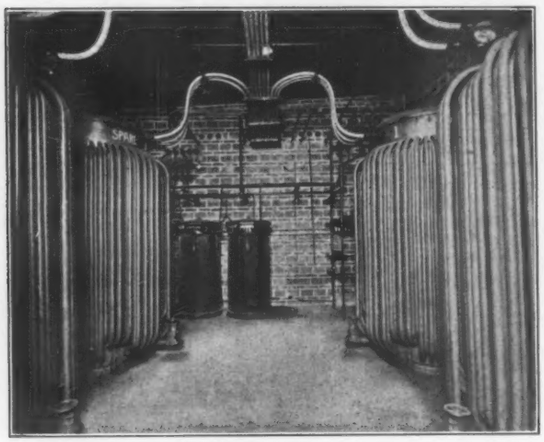


Fig. 4. Lead-covered cable connection on primary and secondary of four 750-kva. 11/2.3-kv. transformers.

years ago the cable installation was made and no trouble whatever has been experienced since, and maintenance costs have been reduced 99 per cent.

Transformers ranging in size from 1 kw. to 750 kw. have been connected in this manner during the past six years with no resultant trouble whatever. The only change necessary to fit the overhead-type transformer for lead connection is the substitution of a brass wiping nipple for the porcelain bushing.

The Determination of Temperatures in Underground Cables*

By G. L. HILL

There are many methods of measuring temperature, the mercury thermometer being the most common of all. The method used depends upon its aptability to the particular problem and accuracy required. An example of extreme accuracy is the bolometer invented by Dr. Langley and used by the Smithsonian Institute in the measurement of radiant heat from the sun's rays. This instrument will detect a change of one millionth degree centrigrade.

However, in cable-temperature work a measurement within one degree centigrade generally is of sufficient accuracy. The methods best adaptable to cable-temperature measurements both are electrical methods: The thermo-electric circuit and the effect of temperature upon the conductivity of certain electrical conducting materails, such as copper.

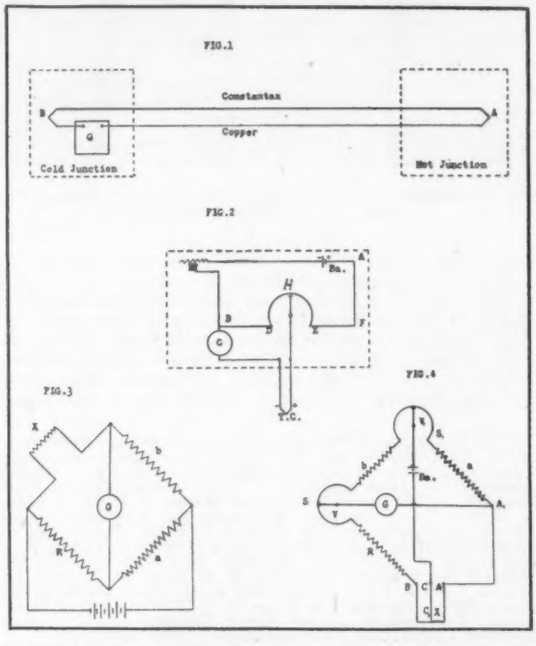
Thermo-Electric Method

Fig. 1 shows an elementary circuit of a thermo-electric pyrometer. In measurements embodying this principle one couple, A, is placed as closely in contact with the hot body as possible. In metals, such as lead sheaths, it is advisable to solder or wipe directly onto the sheath. This is called the hot junction. The cold junction, B, is in the manhole or on the street. This is necessary to complete the circuit. In practice the thermocouple leads, such as copper-constantan or iron-constantan are run to the instrument shown as G, which becomes the cold junction.

The voltage set up in a circuit, such as that of Fig. 1, is a measure of the temperature difference between the cold junction and the hot junction. This voltage may be measured with an instrument of the d'arsonval type or the voltage may be measured with a potentiometer. Where an instrument of the d'arsonval type is used the resistance of the leads affect the readings and if long will cause appreciable error. For this reason the potentiometer type of instrument, either indicating or recording, is preferable.

The selection of metals to be used in making up the thermocouples depends upon the conditions of the tests. For low temperatures either iron-constantan or copper-constantan generally are used. Copper is preferred to iron due to its lower resistance and the corrosive effect upon iron of the dampness in manholes and ducts. Special standardized thermocouples may be obtained, but if a good grade of therocouple lead wire is used, the lead wire itself may be used also as the thermocouple. This is done simply by soldering or brazing the two wires together at the end used as the hot junction. The other end goes to the instrument terminals.

Fig. 2 shows the elementary diagram of the potentiometer referred to in the description of the thermo-electric circuit. First, it provides a means for securing a known variable potential, and second, suitable electrical connections for opposing that potential to the unknown electro-motive force of the thermocouple. The thermocouple is at TC with its polarity as shown and the galvanometer G is connected in the thermocouple circuit. A current from a dry cell B_a is flowing continuously through the main circuit A, R, B, D, H, E, F. Section DHE of this circuit is a slide wire of uniform resistance throughout its length. The current from the battery sets up a difference in potential between D and E. As H is moved, the difference of potential is varied between D and G and this is in opposition to the thermocouple e.m.f. When the galvanometer shows a bal-



Figs. 1, 2, 3, 4. Connection diagrams for various methods of cable-temperature determination.

* Report prepared for the underground systems committee.

ance the millivolts may be read from the scale or, if calibrated, degrees may be read directly. A standard cell, automatic cold junction compensator and other improvements are provided in a complete potentiometer.

Change Of Resistance Method

It is the characteristic of all pure metals that they change their resistance with changes of temperature and it is of this property that use is made in the resistance method. This change of resistance can be measured by several methods. One is by measuring the drop of potential when a known current is passed through the conductor, measuring with a voltmeter and an ammeter. There are other methods, but the most common is the Wheatstone bridge. This is the most reliable and accurate method for all ordinary resistances met with in cable work.

Fig. 3 shows an elementary circuit of a resistance thermometer. The exploring coil X consisting of copper, platinum or iron, is placed in one arm of the bridge. The bridge is placed at the point where the indication is desired and the exploring coil is placed at the position where it is desired to measure the temperature. The instrument G may be arranged to show the unbalanced current or, by adjusting the bridge arms, the instrument may indicate when the condition of balance has been reached.

If the leads to the exploring coil X always were short a simple Wheatstone bridge might suffice, but in some cases the leads may be of comparatively great length and a considerable error would result.

Fig. 4 shows a special Wheatstone bridge that overcomes the objections of that of Fig. 3. The electromotive force of the battery B_s is applied to the points V_1 and C_1 and causes a current to flow through b, S and R, and another current through S_1, a and X. One terminal of the indicator, generally a galvanometer, is connected to A_1 and the other to a conductor which can be slid along the resistance S_1 until a point is found having the same potential as A_1. When the condition of balance has been reached the resistance X is the same fraction of the right-hand circuit that the resistance R is of the left-hand circuit. The point V_1 also is movable on the slide wire S_1, thus the combined resistance of $S + b$ at all times is equal to $S_1 + a$, X then is equal to R plus the resistance of that part of the slide wire up to the point V. A scale placed alongside of S therefore can be used to measure the increments of the resistance X, hence the degree of temperature.

It may be seen that the bridge of Fig. 4 is independent of battery voltage fluctuations, thus permitting a dry cell to be used as the source of potential. The bridge may be either indicating or recording and by suitable switching arrangement one indicating instrument may be used for several exploring coils.

Drop of Potential Method

Fig. 5 shows a method of temperature measurement used by the engineering department of the Pacific Gas and Electric Company where it is possible to make a test on newly installed cable before it becomes necessary to put the cable into active service. The cable is pulled into the duct system and spliced. Splices are the same as used in actual service except they are not insulated for higher voltages. A 3-phase source of power is installed at a suitable manhole as shown at manhole No. 4. The cable is short circuited at manhole No. 1 and a current is sent through the cables in accordance with the desired loading.

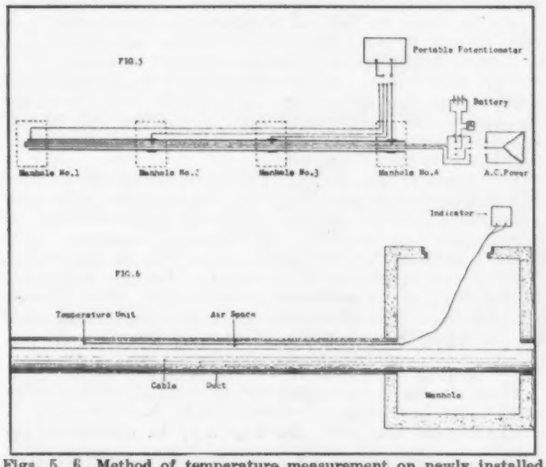
Potential leads are brought out from each splice, the lead being connected to the same conductor at each splice. A source of d.c. power is provided to measure the resistance of the conductors while the a.c. power is pulled off momentarily. To obtain the drop of potential for any section, say between manholes No. 2 and No. 3, it is neecssary only to pick out the proper leads at the terminal board. To measure this potential a potentiometer should be used because the resistance of the leads will cause serious errors if a millivoltmeter is used.

This test gives the average temperature of the conductor for different loadings and is most valuable in that it determines the possible loading for the cables and duct system. Also if thermocouples are wiped onto the sheath at the time the cable is pulled in, the temperature gradient may be obtained for different loadings. When the cable is placed in service, readings may be taken of the sheath temperature and the temperature gradient corresponding to the load added to the sheath temperature to give the conductor temperature. Two tests of this nature have been made recently by the Pacific Gas and Electric Company, one involving 10,000 ft. of cable and another involving 4,800 ft.

Temperature Surveys

Fig. 6 shows a typical method of making a survey. A temperature unit is pushed in beside the loaded cable as far as possible. Carpenter's folding rules riveted together have been found handy for this purpose. Readings of temperature are taken with an indicating or recording instrument simultaneously with the load reading at the station and plotted with time as abscissa and load and temperature as ordinates. Actual temperature and load data taken in a survey are shown in Fig. 7 and 8. Fig. 7 gives the sheath temperature as well as the air temperature in the loaded duct. At this particular manhole a thermocouple had been soldered onto the sheath. This cable was loaded intermittently as shown by the load curve which, at the time of test, was the 24-hr. load cycle of the cable. Fig. 8 shows a test made where there were several cables in the duct system, the load being on continuously. It may be noted in Fig. 8 that only air temperatures are given. These are the temperatures of the air beside the loaded cable and in the empty ducts; there were no temperature units on the sheaths at this location.

Fig. 7 and 8 are given merely as examples of typical results of temperature surveys rather than for any specific values. One shows the temperature of a cable sheath isolated from other cables, the other shows the temperatures of loaded ducts with practically continuous load and also shows the effects of the load of adjacent cables. In all temperature surveys the ultimate purpose is to obtain the "hot-spot" conductor temperature. Empty duct temperatures are an indication of the duct-system temperature, but when cables in the system are of various sizes and carrying variable loads



Figs. 5, 6. Method of temperature measurement on newly installed cable (5). Typical arrangement for cable-temperature survey (6).

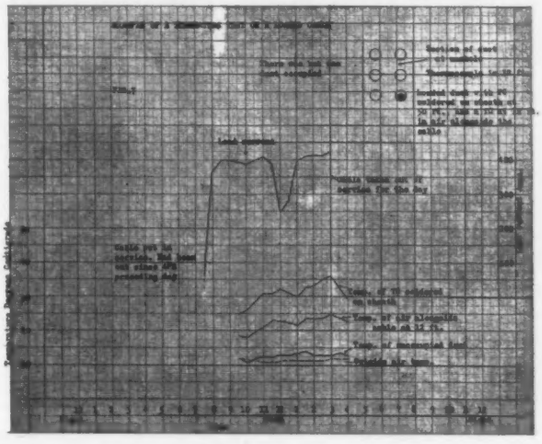


Fig. 7. Example of temperature test on a loaded cable.

it becomes diffcult and in fact nearly impossible to determine what gradient to add to the empty-duct temperature to obtain the conductor temperature of the cable in question.

The problem then becomes a matter of getting as close to the conductor as possible. If feasible the air temperature in the loaded duct should be obtained.

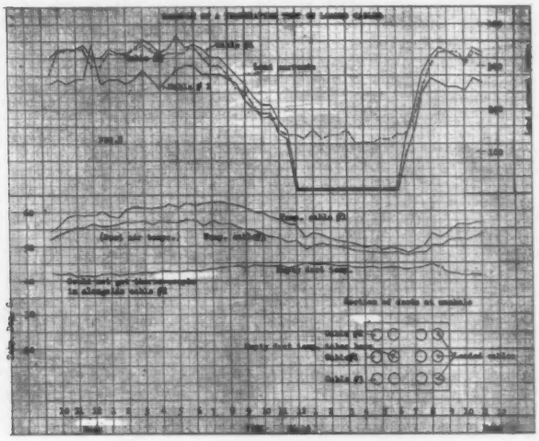


Fig. 8. Example of temperature test on loaded cables.

When this temperature is measured there arises the question of what gradient to add. This question may be answered by setting up a laboratory test using a short piece of similar cable.

Fig. 9 gives a temperature-gradient test made on a short piece of cable. This was conducted in the open room with air as the only insulator around the fiber duct. Fig 10 gives the temperature gradient of the same piece of cable except that the fiber duct was insulated with two layers of 1-in. felt. It may be seen that for a given load current the temperature of Fig. 10 is higher than for Fig. 9. This simulates field conditions where the thermal conductivity changes due to the variable moisture content of the mass surrounding the duct section. Fig. 9, 10 and 11 are given as examples of tests and not for specific values.

When temperature measurements are made during a survey of a loaded cable or duct system the physical conditions are unknown. A reading is obtained and if the unit is not wiped to the sheath it represents a temperature somewhere between the sheath and the duct wall. It still becomes a problem to determine what temperature to add to the field reading. But the desired goal is much nearer than when measuring the empty-duct temperatures. A very good method for determination of the necessary gradient to add is to calculate the I^2R for the different laboratory tests and plot this against the temperature difference. This will give curves similar to Fig. 11. The gradients to the air spaces, such as the mid-point between sheath and duct wall and the inner duct wall also should be plotted. Then calculate the I^2R for the field test, obtaining the R from an estimated temperature and the I from the station log sheet. For this I^2R (plus any other losses such as approximately ½ the dielectric loss if known) obtain the corresponding gradient from Fig. 11 and add it to the field reading to obtain the conductor temperature. With this temperature a corrected R may be obtained and a corrected I^2R calculated, thus obtaining a corrected temperature gradient to add to the field reading. This correcting process may be repeated again if warranted. The question of what currents to use in calculating the mean I^2 is a matter to decide for each case. On overload peaks of short duration the gradients will increase somewhat due to the lag between conductor and sheath, and sheath and air temperatures. The laboratory tests represent stable conditions of temperature when the readings are taken.

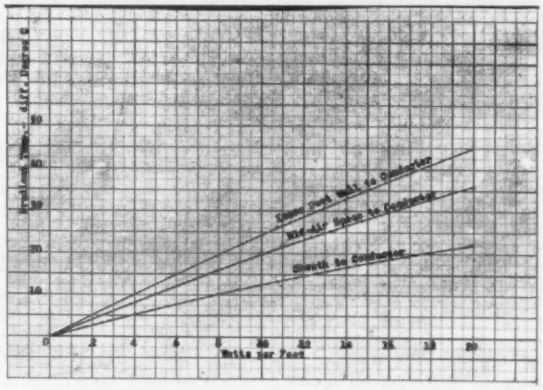
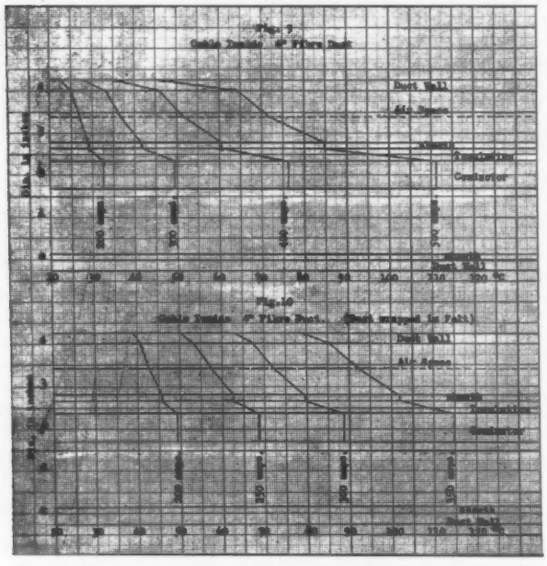


Fig. 11. Example of temperature-gradient curves.



Figs. 9, 10. Temperature-gradient test on a short piece of cable (9). Same test on same cable except that fiber duct was covered with two layers of 1-in. felt (10).

The above gives a simple and practical method of temperature surveys. It is recommended that temperature units be wiped to the sheaths at various locations, thus making the measurement of the temperature a more definite operation. The question of what gradient to add to the readings then is simplified and the final results are more accurate and reliable.

It is not necessary to have the temperature unit any great distance from the manhole walls to obtain the higher temperatures. Tests have shown that the temperature of the sheath, when plotted for the whole longitudinal section between manholes, shows a more or less flat characteristic throughout the length after the first 10 or 12 ft. In some cases the temperatures have been higher near the manhole than in the center of the duct section.

As to which method of temperature measurement to use, it may be said that either is good and hence it is a matter of individual choice. Almost any method is better than none. As to economy, the thermocouple method has the advantage. The leads cost about the same, but the resistance units cost from $15 to $20 each, whereas the thermocouple unit is made by soldering the two wires together.

For temperature surveys the engineering department of the Pacific Gas and Electric Company uses two portable potentiometers and one 12-point potentiometer recorder and one 8-point potentiometer recorder. The 8-point recorder is equipped with a 12-volt d.c. motor. This is for operation in manholes, the d.c. being obtained from two 6-volt storage batteries. Two Wheatstone bridges are available and some resistance units are on hand, but are not used at the present.

Rating Of Cable from Temperature Tests

From the large bibliography* on the subject it may be seen that the rating of cables lends itself readily to mathematical analysis. Ratings may be calculated for

* Two good bibliographies will be found in the appendicies of the following papers:

a certain cable or may be obtained from published tables. They all are based upon certain assumptions such as the allowable temperature rise, the thermal resistivity of the insulation and the resistivity of the surrounding mass of the air, concrete and earth.

The fundamental ohms law for heat-flow from a cable is as follows:

$$H = \frac{t}{R_i + R_g}$$

where H = heat developed in the conductor, in watts.
R_i = thermal resistance of the insulation.
R_g = thermal resistance of the mass surrounding the cable.
t = temperature rise of the cable.

Values for R_i and t may be obtained for a given cable, the value of t being an arbitrary value which has been adopted by the A.I.E.E. standards.

There remains the value for Rg which must be obtained before the allowable carrying capacity H of the cable is known definitely. Rg depends upon such variables as the moisture content of the earth, type of duct construction, etc., and is very difficult to obtain. The variable moisture content may increase or decrease the rating as much as 50 per cent. For this reason is seems advisable to rate cables from results of actual temperature surveys. After the temperature survey is made and the conductor temperature is known for various locations, the question of whether the rating of that particular cable-and-duct system should be increased or decreased may be determined.

If a temperature-load test can be made on a certain cable-and-duct system (as outlined in Fig. 5) the rating will be known before the system is put into service. At the time of the test heating and cooling, curves should be taken and from these the permissible emergency rating may be deducted. It is advisable to use the same or similar cable in the temperature-load test that is to be used in service. A small conductor, if used as a heater for a test, will give an entirely different emergency-rating factor than a large lead-covered cable for the same I^2R input. This is due to the different thermal time-constants of different sizes of conductors and designs of cable; also to the different ratio of the capacity for heat to the radiating surface.

Another method of determining the possible emergency rating of a cable or cables is to switch the load between stations in such a manner as to place a heavy load on the cable in question. Then measure the sheath temperature at various locations with recorders and calculate the conductor temperature from these readings as the test progresses. This test will give the peak-load rating of the cable at very little expense and will be helpful when it is necessary to load a cable to a high current value in an emergency.

From the foregoing discussion it is hoped to point out the advantages of periodical temperature tests and surveys. A large investment may be saved by operating at or near the proper temperature. Cable failures often are attributed to high temperatures where no other explanation is known. Where definite temperature records are kept they will help clear up causes of failures and prove of economic value.

1. The Effects of Moisture on Thermal Conductivities of Solids, with a Bibliography on the Heating of Cables. By Shanklin, A.I.E.E. Journal, February, 1922.

2. Calculation of the Electrical Problems of Transmission by Underground Cables, with a complete Bibliography on Cables. By Simons, The Electric Journal, August, 1925.

Cable Laying in San Francisco Bay*

By G. H. Hagar

In October, 1926, the Great Western Power Company laid its fifth cable across San Francisco Bay. It is part of an 11-kv. tie between the Golden Gate substation, terminus of transmission lines on the Oakland side, and the Beach and Mason station in San Francisco. The cable itself is approximately 41,000 ft. long. Cable specifications are:

500,000 circ.mil stranded copper conductors.

12/32 in. of special 40-per-cent high grade rubber, taped.

Jute fillers and serving.

No. 4 BWG galvanized armor wires.

Three twisted pairs No. 14 stranded copper telephone conductors.

3/32 in. of 30-per-cent para insulation around each conductor.

The cable was manufactured in the East in 1,200-ft. lengths, spliced, and then armored into 4,800-ft. lengths for shipping. It received a factory test of 28 kv. between conductors and ground for 5 min. The telephone wires received a 4-kv. test between conductors and also between conductors and ground for 1 min.

The shore ends on each side of the bay are of the same design except that the main conductors are 750,000 circ.mil instead of 500,000 circ.mil. This is to

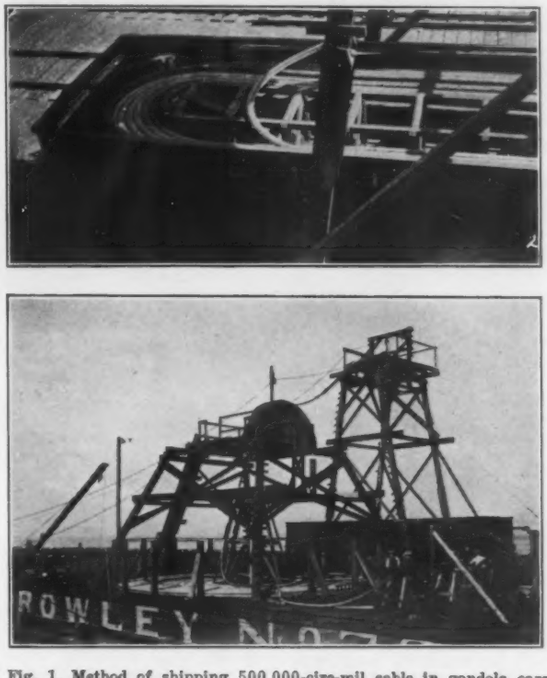


Fig. 1. Method of shipping 500,000-circ-mil cable in gondola cars (above). Rigging for unloading and coiling cable (below).

compensate for the lower cooling effect of air than that of water.

Method of shipment and the rigging used in unloading cable from the cars and coiling on the barge are shown in Fig. 1. The cable was raised vertically and run over a drum (large cable reel) and thence over a half-round frame with running sheaves set on an arc of a circle, droping from there to the deck of the barge where it was coiled.

Fig. 2 shows the coiling of the cable on the barge. This method of coiling loosens the armor wires, throwing out one-half of a turn in the lay for each complete circle on the deck of the barge. When laying, the process is reversed and the half-turn thrown back into the armor wires.

The 4,800-ft. lengths were spliced together. In the lower portions of Fig. 1 may be seen a splice just completed. Each splice was tested to 12 kv. between conductors and between conductors and ground before the next splice was made. The type of splice used was that described in a report of the P.C.E.A. underground systems committee for 1925-26.

The 750,000-circ.mil shore ends were laid with a small barge and anchored during the time the main cable was being coiled and spliced. The outer end of shore length on the San Francisco side was tied upon staging erected under a pier. That on the Oakland side was laid in the water and the end buoyed.

The end of the main cable was anchored temporarily alongside the end of the shore length, ready for splicing. The start was made from the San Francisco side at slack tide as the current there is very strong. Effect of tide on the Oakland side is very small. The maximum depth of water on the San Francisco side is 90 ft. The other side is comparatively shallow.

Three sea-going tugs were used in the deep water, one towing and two abreast, for absolute control of the

* Report prepared for the underground systems committee.

course taken. When the water became too shallow for these tugs they were changed one at a time for three light-draft tugs. This changing of tugs took about 12 min. The time for laying the eight miles of cable was 2 hr. 35 min., including changing the tugs. The only

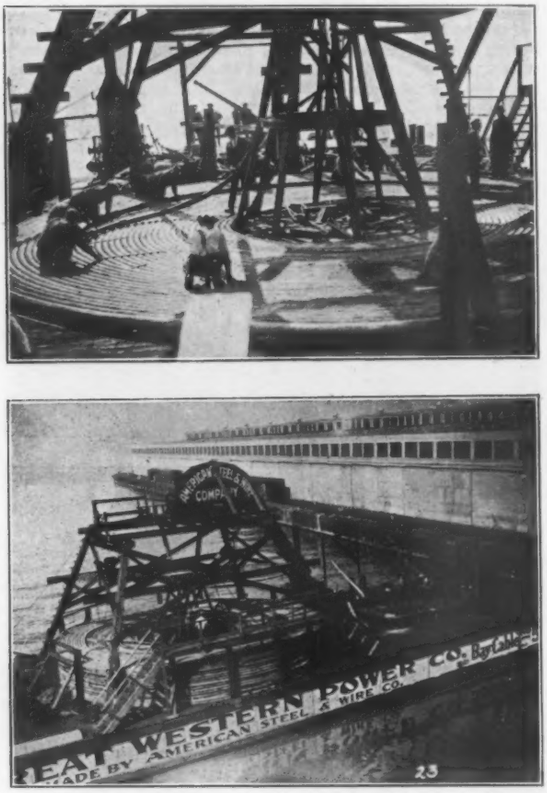


Fig. 2. Details of coiling cable on deck of barge (above). Entire cable on board the barge (below). In the latter it may be noted that the top semi-circle of sheaves has been swung around at right-angles to the loading position and is in line with the cable chute and brake blocks. Note the brake handles.

incident of the trip was the periodic raising of the brake blocks to allow the splicing sleeve to slide through at the end of every 4,800-ft. length. The preparation was a matter of weeks, the laying a matter of minutes.

Concrete Duct Spacers in Conduit Construction*

By C. H. JENKINS and C. G. MANSFIELD

In August, 1926, the Los Angeles Bureau of Power & Light adopted as standard practice the use of precast concrete spacers in conduit lines. Practical experience in the use of this method of construction has been obtained, as well as some data on the relative costs of this and former methods. Details of the spacers used with 4-in. fibre ducts are shown in Fig. 1.

The appearance of a typical installation before concreting is shown in Fig. 2. The outstanding advantages of this type of construction are that the spacing between ducts is fixed definitely without any particular effort on the part of the workmen, and that concrete may be poured continuously, since the operation is entirely independent of the placing of the ducts. This results in an appreciable reduction in the lost time for both men and machine and hence reduces construction cost.

Spacers are placed in the line at intervals of approximately 4 or 5 ft. The use of a spacer on top of the duct stack makes it possible to increase the rigidity of the structure by tying the top and bottom spacers together with a loop of wire. Further this top spacer forms a convenient guide in surfacing the conduit. Overhanging ends of spacers keep the ducts properly centered in the trench and insure a concrete envelope of the proper minimum thickness.

While the improvement in quality of the finished conduit is an attractive result of this type of construction, the cost also is a matter of importance. It is rather difficult to obtain cost data which will reflect accurately the difference due to the use of spacers independent of other effects. However, the following data have been selected with some care and it is believed that they fairly represent the relative costs of this and the tier-by-tier method formerly used.

Checks made on several runs of 16 and 20-duct conduit aggregating 665 conduit-ft. laid with spacers by a crew of 17 men gave 19.2 duct-ft. laid per man-hour. This figure covers placing the ducts, mixing and pouring concrete, and the making of the spacers, plus a small allowance for the reinforcing wire and the extra cement required for the richer mixture used in the spacers. It does not include the foreman's time or the incidental labor not directly involved in laying the conduit.

On the same basis the corresponding figure for conduit laid by the tier-by-tier method formerly used is 12.8 duct-ft. per man-hour. This value is derived

* Report prepared for the underground systems committee.

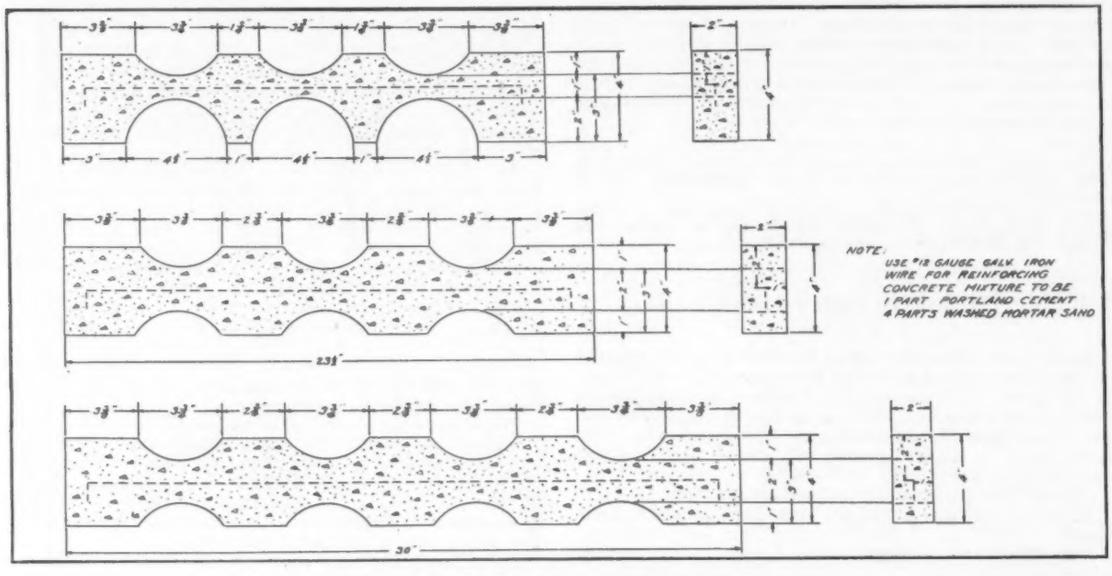

NOTE.
USE #18 GAUGE GALV. IRON WIRE FOR REINFORCING
CONCRETE MIXTURE TO BE
1 PART PORTLAND CEMENT
6 PARTS WASHED MORTAR SAND

Fig 1. Design details of concrete duct spacers.

from average costs on a large amount of construction and is subject to some error due to lack of knowledge as to exactly what items were included in the costs as reported. After making proper allowance for such uncertainties, however, the difference of 50 per cent between the figures given indicates that the use of the spacers has speeded up the work. On the basis of labor at 50 cents per hr. the cost of this part of the work is 2.6 cents per duct-ft. with spacers and 3.9 cents per duct-ft. without spacers. The percentage difference between the two methods of course will be much lower when figured upon the total cost of the conduit, since the material cost is not affected.

Spacers are cast in wooden forms each of which makes two spacers. The forms are oil treated and

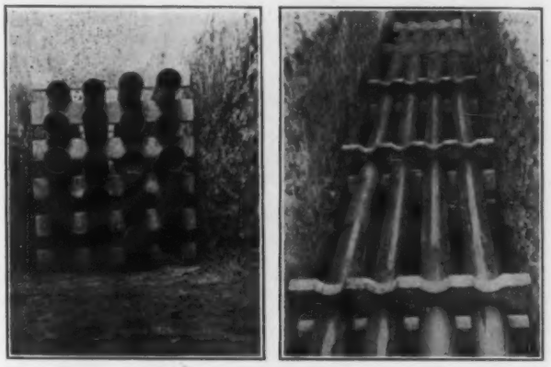


Fig. 2. Two views of a duct line laid with concrete spacers.

the sides are removable so that the completed spacers can be released easily and with minimum breakage. One or two men are employed in making the spacers, depending upon the amount of construction in progress. These men cut and form the reinforcing wire, clean and oil the molds and mix and pour the cement. The cement is made as dry as can be poured readily and may be removed from the mold with little danger of breakage after four hours. This permits the forms to be filled twice a day so that one man, using 30 forms, can make about 120 spacers per 8-hour day. The men employed on this work receive 50 cents per hr. and the direct labor cost therefore is about 3.33 cents per spacer. The mixture used in the spacers contains about twice as much cement as the concrete which it displaces in the conduit and the extra cost due to this and the reinforcing and binding wires amounts to about one cent per spacer. Making a small allowance for incidentals, 4½ cents per spacer would seem to be a fair value to use for estimating purposes.

High-Transmission Cables in Los Angeles*

By C. H. JENKINS and C. G. MANSFIELD

Three new 33-kv., 3-conductor cable lines have been placed in service recently by the Los Angeles Bureau of Power & Light bringing the total amount of such cable in operation on that system to about 30,000 ft. Other 33-kv. cable lines aggregating about 38,000 ft. are being installed and will be placed in service in the near future. Two of the new lines extend from Central receiving station No. 1 to distribution station No. 12 on East Fourth Street, which serves a large part of the principal business district of the city. This station is in process of reconstruction, and when the changes are completed its entire load will be carried on three 33-kv. cable lines from central receiving station No. 1, with one tie line of the same type to distribution station No. 9. The third of the new lines extends from central receiving station No. 1 to the corner of College and Adobe streets where it connects to an overhead line.

All of the new lines are installed in special conduit lines of 4½-in fibre ducts, the number of such ducts varying from 4 to 8 in different parts of the line. Each main duct is accompanied by a 2½-in. auxiliary duct for the pilot cable which is used in the protective system. A typical duct arrangement in an 8-duct section is shown in Fig. 1. It may be noted that the main ducts are grouped in two vertical rows with the pilot cable ducts and an earth fill between. This type of section was adopted to improve the

Fig. 1. Typical 8-duct construction for 33-kv. cables.

heat dissipating ability of the line. It is used on the 8-duct lines only. Temperature measuring units were embedded in the conduit at several points at which it seemed probable that maximum temperatures might result from the proximity of other heat sources such as conduit lines or steam pipes. The average and maximum span lengths on straight runs are 350 and 400 ft. respectively, and the minimum radius of bend on curves is 35 in.

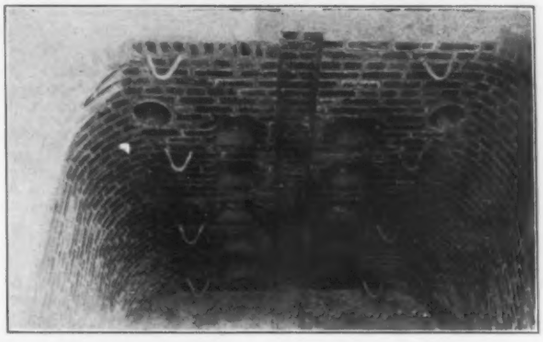


Fig. 2. Looking down into a manhole showing the duct ends.

Manholes have brick walls, concrete floor and concrete roof. Each is divided into two similar compartments by an 8-in. reinforced concrete center wall. Separate 30-in. entrances are provided for the two compartments, each of which is 3½ by 7 ft. The depth varies from 5 ft. 10 in. on the 4-duct lines to 8 ft. 6 in. on the 8-duct lines. Half of the total number of ducts enter each compartment and are fanned out in a vertical plane to 16-in. centers so that the cables are brought to the desired positions on the center wall without bends. Figure 2 shows the appearance of the ducts in the end of a manhole before the center wall was constructed. The two large holes near the top are ventilators. Each joint with attached cable is enclosed in a housing of 10-in. concrete tile, having a 1-in. wall, which extends from

* Report prepared for the underground systems committee.

end to end of the manhole. The tiles are split longitudinally to facilitate assembly and are held together by strap-iron tile clamps. Figure 3 shows the complete housings on two joints.

The cables just placed in service have 400,000-circ-mil sector-shaped conductors with 2 3/64-in. conductor insulation and 9/64-in. of belt insulation.

Cables to station No. 12 are impregnated with hard compound while the one to College and Adobe

Fig. 3. Concrete tile housings over 33-kv. cable joints.

streets is impregnated with a soft compound. Great care was taken to insure uniform and careful workmanship in the installation of the cable. All of the joints were made up by one man who was selected largely because of his conscientious attention to detail. No attempt was made to establish a record for speed in assembly. Joints were made in accordance with specifications furnished by the cable manufacturer which call for paper tape over the connector to a diameter equal to that of the factory insulation, a 2½ x 9 in. treated-paper-tube barrier around each conductor, and a 6½-in, treated-paper cylinder 16 in. long surrounding the three conductors. The lead sleeve is 8 in. in diameter and 30 in. long.

In the reactor house at central receiving station No. 1 and in station No. 12 the cables are terminated in 3-conductor flat-type cable terminals. The short runs from the reactor house into central receiving station No. 1, and from the manhole at College and Adobe streets up the pole to the overhead line are made with 500,000-circ-mil single-conductor cable having 16/32-in paper impregnated with soft compound. This arrangement requires the use of a combination joint in the College and Adobe Streets manhole. All of the joints and terminals are filled with D-1 compound. Glass expansion reservoirs of about 2½-qt. capacity are installed on all of the joints in the soft-compound cable and on the terminal at the high end of each run. These reservoirs are filled with high-grade transil oil. The oil reservoirs on the joints are sealed under a slight pressure at the time of installation while those on the terminals are open to atmospheric pressure.

Kenotron tests were made on all three of these cables before they were placed in service and will be repeated at intervals of about a month in the hope of detecting incipient faults before they result in outages. A 4-tube Kenotron set was used, the general arrangement and connections of which are shown in Fig. 4. Each tube is designed to pass ¼ amp. at 50 kv. Voltages up to 200 kv. can be obtained by connecting the tubes in series as indicated in the circuit diagrams. Each tube is mounted on an insulating post on the top of a filament transformer the windings of which are insulated for the full voltage of the set. The filament current is controlled by resistance in the grounded winding of this insulating transformer. Each tube is shunted by a safety gap to prevent destruction of the tube in case an excessive voltage accidentally is applied to its terminals. Connections between the tubes are made by means of telescoping metal rods as shown.

Eventually the complete Kenotron set will be mounted on a truck so that it can be moved readily to any point at which a test is to be made. In the tests on these cables, however, the tubes were set up near the cable terminals on the floor of the underground reactor house and the control board and transformer were installed in a small building directly above the reactor house as shown in Fig. 5. Before applying the test voltage the copper temperature was raised to about 49 deg. C. by circulating low-voltage d.c. at about 450 amp. per conductor through the cables for 1 hr. 35 min. to facilitate the flow of

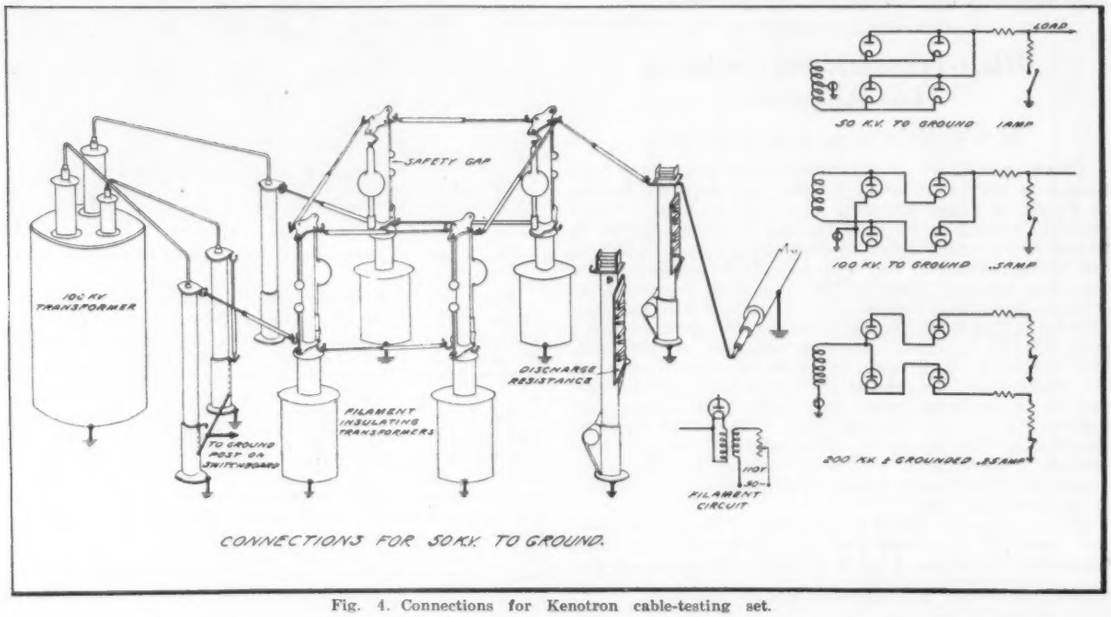


Fig. 4. Connections for Kenotron cable-testing set.

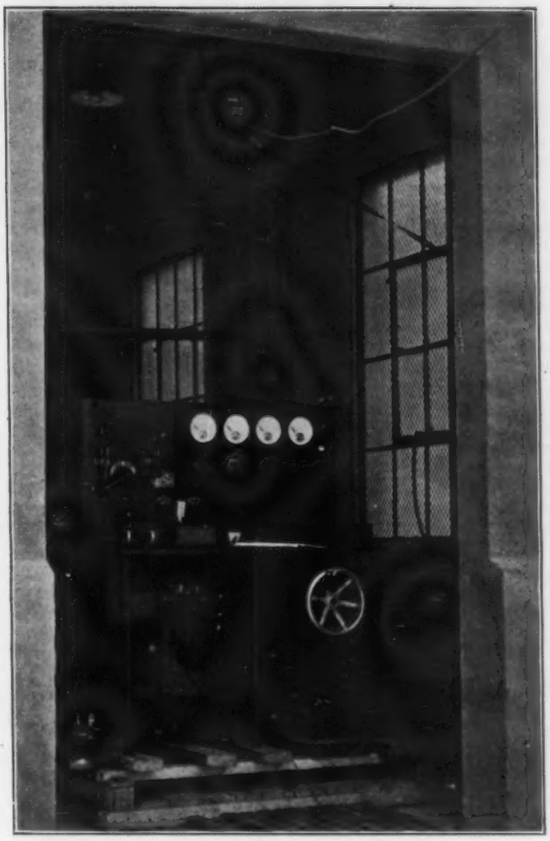


Fig. 5. Control board for Kenotron set.

compound into any voids which may have developed in the insulation during installation.

The method of making the tests followed closely that described by Phelps and Tanzer on page 54 of the A.I.E.E. Transactions of 1923. Voltage was raised to the desired value at as nearly a uniform rate as possible during the first 30 sec. after closing the switch. At the end of this period the initial current reading was taken, followed by others after 15, 30, 45 and 60 sec. and at 1-min. intervals thereafter to a total time of 10 min. There was a small difference between the voltages in the several tests due to the drift of voltage which occurs after the controls are brought to rest and which cannot be estimated exactly. As the current falls off there is a further slight increase in voltage due to the varying voltage drop in the tubes.

Results of the tests on the three lines are shown on the curves in Fig. 6. Test voltages were kept low enough to avoid the possibility of damaging the insulation and the actual magnitude of the observed currents is not of any particular significance so far as is known. It is expected, however, that any partially-developed faults in the cable will result in the appearance of humps or other changes of shape in one or more of the curves.

In addition to the regular tests described above it is expected that the set will be used for fault reduction and possibly in the location of high-resistance faults by a high-voltage bridge method. No definite progress along these lines can be reported as yet.

Underground Construction in San Francisco*

By R. P. LUTZI

The development of a system of a.c. distribution of reliable character to supply increasing load, especially in the congested areas of the larger cities, is a problem of great importance to the central sta-

* Report prepared for the underground systems committee.

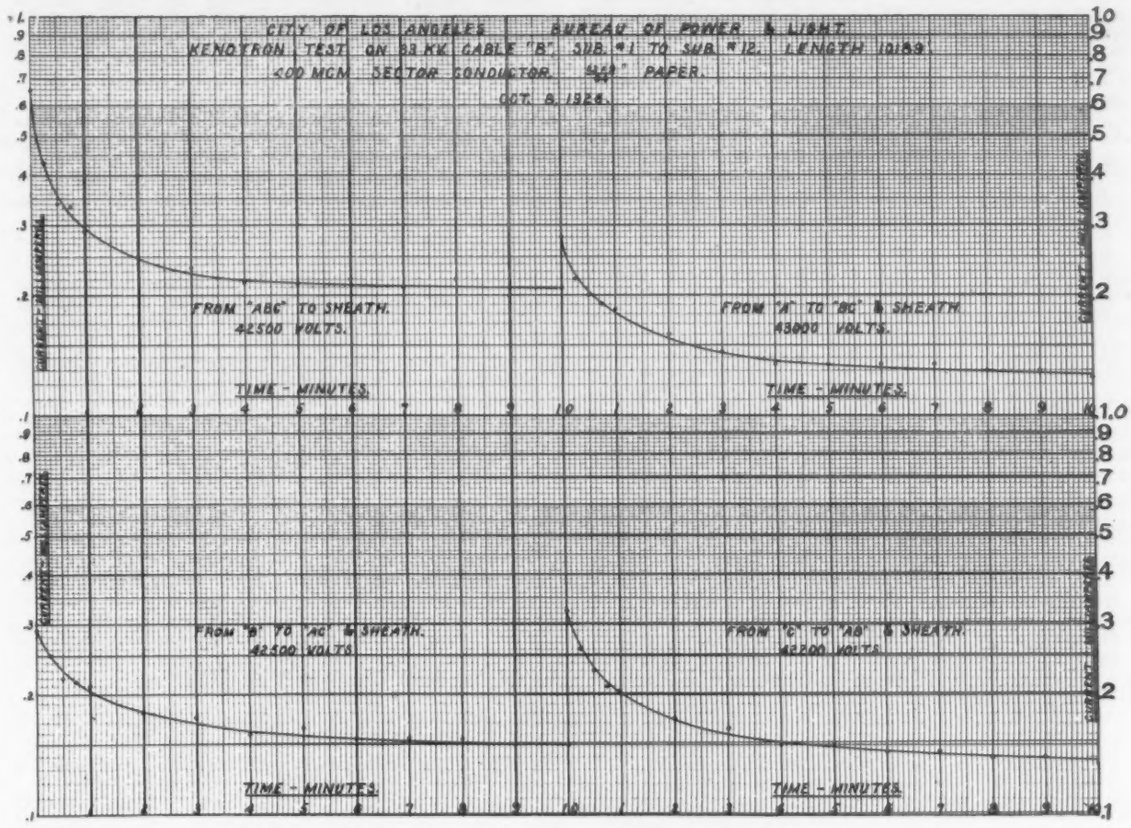

CITY OF LOS ANGELES BUREAU OF POWER & LIGHT
KENOTRON TEST ON 33 KV. CABLE "B" SUB #1 TO SUB #12. LENGTH 10189'
500 MCM SECTOR CONDUCTOR. 4½" PAPER.
OCT. 8, 1926.
FROM "ABC" TO SHEATH. 42500 VOLTS.
FROM "A" TO "BC" & SHEATH. 43000 VOLTS.
FROM "B" TO "AC" & SHEATH. 42500 VOLTS.
FROM "C" TO "AB" & SHEATH. 42500 VOLTS.
TIME - MINUTES.

Fig. 6. Typical set of curves from Kenotron cable tests.

tion industry. Conditions that must be dealt with comprise a complex problem. In most cases the development must be made to conform somewhat to the character of the present or existing conditions of supply, retaining the economic advantages in the use of present operating equipment.

In the preparation of this paper no attempt has been made to make any recommendations as to the best methods or particular types of equipment. However, careful consideration has been given to all these and satisfactory a.c. service is being given by the methods now in use. The general type of system is the same for both overhead and underground distribution although this report will deal principally with the latter.

The distribution system in San Francisco now is supplied from 11 substations located at various points about the city and inter-connected with 11-kv. tie lines. There are 87 primary feeders radiating in various directions over the territory. All these feeders are underground for at least a portion of their length. All feeders supplying the overhead sections leave the various substations in duct lines and later terminate in the aerial system by means of risers.

When the original installation of the 2-phase, 2.3-kv. primary had outlived its usefulness and after careful consideration it was decided to rebuild the system using the 3-phase 2.3-4.1-kv. system for the primary feeders and the 120-240-volt distribution for lights and small power consumers. The larger power loads are 3-phase, 3-wire, 240-volt delta. Power loads up to and including 15 hp. are taken on the former where there are no existing power mains.

The primary system consists of 3-conductor cable, using the system neutral in the underground territory. The station lengths as well as the portion of the feeder in congested ducts sections in the vicinity of the substations are of larger size than the remainder of the feeder to prevent excessive heating and to permit the feeders to be loaded to capacity safely. The primary feeders are extended to the centers of distribution where they terminate in junction boxes from which laterals are extended into a network of mains. These mains are interconnected through boxes and oil switches with feeders supplied from other substations, thus enabling load to be transferred from one feeder to the other.

Transformer vaults are inter-connected by a net work of conduit lines and generally are placed at the street intersections. However, a great many vaults are placed in the street or sidewalk area near the location to be supplied. By this method of placing the transformer vaults near the largest load it has been found that a large saving can be made through reducing the size of secondary mains; also maintaining better service to the consumer. Vaults are constructed of concrete and vary in size depending upon conditions. However, it is the practice now to build no transformer vaults with dimensions less than 8 x 10 x 7 ft. Vaults are equipped with a self-ventilating shaft which has proved very satisfactory without the use of forced ventilation. This no doubt is assisted by the fact that weather conditions are favorable. The variation of temperature is small and normally there is a good circulation of the atmosphere. Blowers can be installed easily in these ventilating shafts when conditions demand it. Vaults on which the ventilating gratings are used are constructed with sewer connections.

Most of the substations are equipped with sectionalized buses supplied from separate banks of transformers. The transformer banks at the various substations are not necessarily fed from the same source of supply, this being determined by system operating conditions. Each feeder is provided with an automatic circuit breaker, disconnecting switches, and single-phase regulators with 5 or 10 per cent regulation. From these regulators the feeder is extended to the center of distribution, terminating in a junction box from which the feeder mains radiate. These mains are equipped with manually operated oil switches and sectionalizing boxes at various intervals to allow convenient and speedy operation in transferring load from one feeder to the other and in isolating portions when additional equipment is being installed. The primary junction boxes used are built to accommodate either four or six 3-conductor cables, maximum conductor size, 500,000 circ. mil.

Transformers are connected either to the boxes or multiplied to the main cable, depending upon conditions of operation. They are arranged in such a manner that any transformer installation can be disconnected from the system without interrupting the service. All transformers are protected on the primary side by oil fuses and on the secondary side by link fuses, except on isolated banks supplying individual consumers. In these cases primary fuses alone are used.

Transformers used are standard type 2,300/120-240-volt, connected one phase to ground, for both the single and 3-phase power installations. Straight power is 3-phase, 3-wire delta. Due to the old system of 2-phase distribution it is necessary to continue the supply of 2-phase power at 240 volts. This is done by using a 4,100/240-volt transformer in connection with the lighting circuit.

Secondary boxes used for the lighting circuits are the 2-polarity type with capacities of 500 and 1,000 amp. for power, 3-polarity 600 and 1,000 amp. capacity. The former will accommodate 16 single-conductor cables and the latter 18 single-conductor cables. Maximum conductor on the smaller is 500,000 circ. mil and on the larger 1,500,000 circ. mil. These boxes are equipped with link fuses for all conductors. By proper selection of fuses for the various mains and services any trouble may be localized immediately. The various sizes of fuses are chosen for short-circuit, rather than overload protection.

Secondary mains consist of a 2-conductor cable, with the system neutral, for lighting. In cases of 2-phase power or very small loads of 3-phase power isolated from a power bank a single-conductor cable is installed for the third conductor. For installations of 3-phase power, 3-conductor cables are used, making it easy to distinguish the lighting from the power circuits. When cable of 500,000 circ. mil or larger is required, single-conductor cable has been found more applicable.

Transformer sizes as well as size of the transformer bank is determined by the load in various sections and the condition of balance on the primary feeders. The various feeders being tied through a network of mains, which normally are open at various intervals in junction boxes and oil switches, it is very easy to transfer certain sections from one feeder to another, thereby balancing the feeder load as growth demands.

Flexibility of this system is providing for varying conditions of growth and decrease due to alterations and construction of large buildings, is apparent. When the load in any particular section has increased sufficiently to warrant greater feeder capacity a new feeder is extended to the center of distribution and tied into the existing mains. Then by opening at various points the overloaded feeders may be relieved quickly. The adjacent secondary transformer banks are phased for rotation at all operating points. This insures prompt restoration of service in case of any failure in the secondary mains. During the season of peak load, regular load tests are made by use of the split coil as well as the use of the Thermotel. In addition, a careful record is made by the regulation department of all loads added from time to time. By keeping this check it is easy to forestall any overload condition that may impend.

The system as described has proved satisfactory. It has been in operation for some time and reliable service has been maintained at all times.

Purchasing and Stores Section[1]

Section Activities*

By C. D. WEISS

The personnel of the Purchasing and Stores Section is composed of seventeen members, executive heads of purchasing and stores departments of ten class "A" member companies of the association. The section was divided into eight groups or sub-committees to study and prepare papers on subjects of vital importance to our industry.

Six sub-committees reported and papers were prepared on six subjects. Two sub-committees were not prepared to render a complete report and their work was carried over for further study next year.

Activities during the past year have been chiefly concerned with a reorganization of the section and planning further activities to be conducted on a continuity basis, similar to activities of the purchasing and stores division of the American Railway Association.

The subjects selected for study and preparation of papers during the year were: purchasing policies, material control, stores department buildings, facilities and material handling devices, surplus materials, obsolescence and reclamation, inventories, stores organization, and standardization and simplification of stores stocks.

These subjects were selected carefully so as not to overlap the activities of other sections, as the work of a purchasing agent or storekeeper brings him in close contact with all other departmental activities. Therefore the aim of the section is to perfect the activities under its immediate supervision which would inevitably result in many economies in departments benefited.

The purchasing and stores departments are the real "service departments" within utility organizations. What public utility could operate efficiently or pursue proper relations with the public in giving the so-much advertised "service" for which public utilities are now noted, without a well regulated stores department?

Some might be inclined to say these departments must be well organized and equipped now, to be able to serve their respective organizations in their splendid present-day "service program." But pause for a moment and compare stores buildings and facilities with the modern power buildings and efficient generating units and trained construction and distribution units. Are the comparisons favorable? The store, the most ancient "service building of all times" has in the past been overlooked, but we are now beginning to realize "how vital" the store is to our industry. The rapidity and ease with which materials can be secured or issued under proper control with a minimum of red tape through a modern stores departmen has unquestionably minimized capital invested in surplus stocks, reduced operation and construction costs, in addition to improving our relationship with employees and service to the public at large.

[1] **C. D. Weiss,** San Diego Consolidated Gas & Electric Company, chairman. **C. R. Eccles,** Western States Gas & Electric Company, vice-chairman. **The California Oregon Power Company:** I. B. Walther. **Great Western Power Company:** F. R. Sherwood, F. W. Smith. **Los Angeles Gas & Electric Corporation:** W. Maddock. **Pacific Gas and Electric Company:** J. H. Hunt, G. C. Robb. **San Diego Consolidated Gas & Electric Company:** R. E. Thompson, W. deWaard. **San Joaquin Light & Power Corporation:** S. E. Hickman, D. P. Mason. **Southern California Edison Company:** J. L. Gray, F. F. Henry, W. J. McCullough, H. O. McKee. **The Southern Sierras Power Company:** C. A. Kelley, C. B. Lore.

* Report of Section chairman.

Purchasing Policies

By C. R. ECCLES

The purchasing executive make a most important contribution to the success of modern business. A dollar saved in wise and careful buying is considered of more value than a dollar profit because it is a dollar earned over and over again. In fact, the entire structure of cost and profit percentages rests upon a foundation of right purchase, purchase alertness and purchasing policy. Modern business now realizes this fact and the mature technique of purchasing management is developing, and the special requirements of a purchasnig executive are becoming definitely known.

* **Report of sub-committee.—C. R. Eccles, chairman.** J. L. Gray, J. H. Hunt, T. B. Parks.

Qualifications of a Purchasing Agent

In view of the special demands made upon a purchasing manager and the selling pressure brought to bear upon him, a certain definite set of personal qualities seem to be required. He must have the correct temperament for his job. He should possess a natural aptitude, together with his specialized training, to properly perform the duties of his office. He must be a man of foresight and possess a mental alertness that will give him the power of analysis and self reliance. These qualities are essential to good common sense judgment and direct action, vital requisites of the successful buyer.

Ethics

Purchasing ethics are the same as in any other business, "the science of human inter-relationship." An action to be ethical must conform with the principles of right in the abstract, or as known to the world of sports in the phrase "fair play." It must conform to the "rules of the game," simple honesty and the age-old adages, "Do unto others as ye would that men should do unto you," and "A man cannot serve two masters." A purchasing executive should deal as fairly with those from whom he buys as he would expect that person to deal with him, and should never in any way take advantage of the seller when, if conditions were reversed, he would feel it unfair for that seller to take advantage of him. He should never allow his friendship for a seller to interfere in any way with the exercise of sound judgment which should be used at all times for the best interests of his employer. He should never accept favors which would impair the exercise of that unbiased judgment for the best interests of his employer, or which would in any way tend to cause him to extend unfair advantages to other sellers similarly situated but who have not made similar gifts or extended similar courtesies to him.

The purchasing executive should act in all professional matters strictly in a judiciary manner with regard to any purchases he may make and his salary should constitute his only remuneration in connection with such purchases.

He should not accept any trade commissions, discounts, allowances or any indirect profit in connection with the purchases.

He should not, while acting in a professional capacity, at the same time without disclosing this fact to his employer, be a director or shareholder in any company with which he may have occasion to deal. Neither should he act as agent nor in any other way have any financial interest in such a business.

Relations with Vendors

A purchasing executive who fails to extend to salesmen, solicitors and those with whom he has business transactions, or those endeavoring to negotiate business transactions with him, the common courtesies dictated by proper breeding and good manners, is failing to perform his proper duty to his employer. He should at no time overlook the fact that a seller who visits him on a matter of legitimate business is endeavoring to perform his duty to his employer the same as the purchasing executive is endeavoring for his own employer, and that, although he may not be interested in the instant proposition submitted, he may desire in the future to negotiate with the same seller or his employers on some other proposition, and that any discourtesy or ill feeling engendered at any prior meeting cannot help but be to his detriment and to the detriment of his employer. For the purpose of convenience it may sometimes be beneficial to fix definite hours for receiving

sellers, but even under such conditions it may often be advisable to make exceptions where the circumstances require.

The purchasing executive of today must realize that the modern salesman is trained in the analysis of men, that he studies physical appearance, facial expressions, manner of speech, actions, etc., of his prospect, and makes his sales attack in the manner best calculated to appeal to the particular type of individual to whom he desires to make a sale. He must realize that he is the object of a highly concentrated effort of trained salesmen who approach him with a single-minded purpose to sell him merchandise and therefore it becomes most important that the purchasing executive know the technique of sales-approach and prospect-analysis.

The purchasing executive, being in the position of the aggressor, is privileged to demand information while it is the business of the salesmen to furnish the desired data. It is even easier, therefore, for the purchaser to study the salesman than for the salesman to study the purchaser, and the same appearance indicators used by the slaesman may be adopted by the purchasing executive and to them may be added, the business card, the hand clasp, manner of approach, method of presentation and attitude toward defeat. The defense of this sales attack, for it is truly a defense, might be summed up in such qualifications as dignity, energy, courtesy, tact, efficiency, judgment, open-mindedness, etc., for broadly speaking, these are the points that would impress the salesman at first glance. The dignity of the purchasing executive's mein should be such that the salesman will see at a glance the necessity of stating his proposition honestly, concisely and of giving his best price first. No purchasing agent should humiliate himself by entering into price beating discussions. His manner should be neither too friendly nor too rigid, neither suspicious nor gullible, gracious but not necessarily affable, and courteous always.

Tact has been defined by Webster as "Ready power of appreciating and doing what is required by the circumstance, nice preceptions, peculiar skill or faculties." Tact may be inate or acquired, but without it, quality, knowledge, ability and training are practically useless. A man of energy impresses the salesman at once as does his solidity of judgment and open-mindedness.

Bids

Where bids are requested from sellers, closed bids have been more satisfactory. As much judgment should be exercised, before calling for bids, in the selection of those to whom the invitation is extended, as upon the selection of the successful bidder after the bids are received. No bid should be extended to a seller with whom you would hesitate to place an order in the event his bid were found to be successful. Upon the selection of the successful bidder, the question as to whether or not the reasons for the selection of such bid and the rejection of others should be disclosed to the unsuccessful bidder, or to the successful bidder, must be determined in accordance with the facts presented in each instance, and not in accordance with any rule of thumb. What might be good policy from the viewpoint of the employer, or from the viewpoint of diplomatic relationships with the various bidders involved, in one case, might be the poorest of policy from the viewpoint of both in other cases. Bids once submitted should not be allowed to be changed, except under unusual circumstances, as where it has been definitely shown that the change to be made is the result of on error in calculation on the part of the bidder, or error due to improper or misleading information included in the request for bids.

Purchases for Employees

The prvilege extended to employees to purchase through the corporation under reasonable rules and restrictions has proved of benefit to the corporation by increasing its purchasing power and acquainting its employees with the personnel of the seller, as well as bringing a closer relationship between the employees and the corporation through the advantage thus extended to employees. It has also been found that the privilege extended to the employees of securing the advantage of the corporation's purchasing power is the source of considerable information, through employees' friends and acquaintances, as to new and additional markets and advantageous prices for corporation purchases. There are many and varied arguments pro and con in regard to the subject of employees' purchases, none of them without merit. However, the practice properly controlled, plays a very important part in employees' relations and employee welfare.

Public Relations

Purchasing executives, particularly in public utilities, where public relations play so dominant a part in their very existence, will find it advantageous to follow closely the slogan, "Patronize Home Industry," when purchases can be made in the local market of foreign merchandise or of products manufactured in that vicinity, as long as no sacrifice is made in the quality of the product purchased, or unless the price to be paid is considerably higher. Public utility sales markets being restricted to a definite locality, we are dependent upon the good will of those from whom we purchase for a considerable portion of our business, and nothing will go further towards injuring that good-will than failing to assist those from whom you expect assistance. A purchasing executive must use great effort and extreme judgment to see that the local seller and manufacturer is given every possible advantage compatible with good business. By so doing he, being the direct contact between the company and the firms from whom they purchase, can play a very important part in the promotion of public relations and good will by maintaining such standard ethics, rules and policies in the discharge of his duties.

For a brief and concise summary of the subject, no better set rules of standards could be devised than those set forth in the "Principles and Standards of Purchasing Practice as advocated by the National Association of Purchasing Agents"; namely, loyalty to his company; justice to those with whom he deals; faith in his profession.

Material Control*

By H. O. McKEE

When it is considered that many electrical utility companies carry in stock from 15,000 to 30,000 items of material, with inventory values ranging as high as $6,000,000, the importance of material control at once becomes apparent.

The problem of material control is to be able to procure and store the requisite quantity and quality of material at the lowest cost, with the least amount of capital invested.

The responsibility for solving this problem cannot be placed entirely with the stores department, but must be shared by each department authorized to order or use material. However, the stores department, being specialized in the handling of material, must assume the duty of convincing the other departments of the fact that surplus stocks are wasteful, as it costs from 15 to 20 per cent to carry such material in stock.

The principal factors of material control are:

1. The planning of material requirements.
2. The ordering of the requisite material.
3. The purchasing of material.
4. The receiving, storing and issuance of material.
5. The salvaging of material returned to stores.
6. The disposal of obsolete, excessive and scrap material.

The Planning of Material Requirements

The stock card or stock ledger system, with record of material receipts and disbursements for a period of approximately three years, is the principal guide for planning future routine material requirements. From this past history we establish the ordering quantity and the ordering point for routine material demands, carefully considering the smallest quantity which can be economically purchased and the time required to obtain a new supply.

It is self-evident that the stock card or stock ledgers must be complete as to the description of the article, the average monthly consumption and quantities on order, and that the entries of the receipts and disburse-

* Report of sub-committee.—H. O. McKee, chairman. C. A. Kelley, Wm. deWaard.

ments of the material should be kept up to date, so that they will reflect the true condition of the stock at all times. The stock card clerks should be trained to notify the order clerk when the quantities on hand have reached the ordering point. This is done by fastening a red signal tab to the stock card. The order clerk may then ascertain at a glance the items

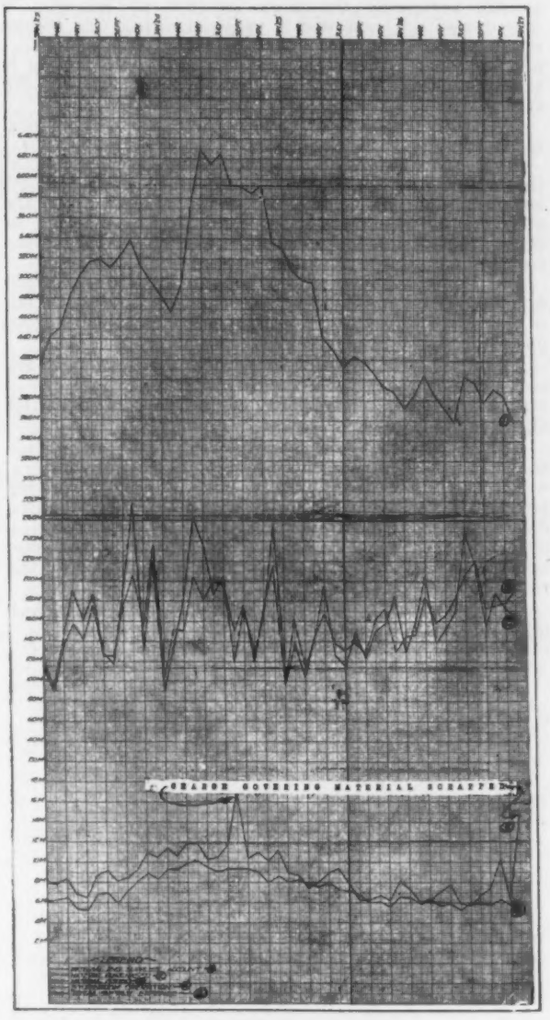


Fig. 1. Curves showing results of "material control" system.

which are to be ordered. This work also is supplemented by the storekeepers notifying the order clerk when the material in the bins is low.

The ordering point, as defined by Madison Cartmell, in his book on "Stores and Material Control," is the quantity required for average or expected consumption during the time ordinarily taken to obtain a new supply, plus a margin of safety.

The annual budget of the construction and operating expenditures is the other guide for planning future material requirements. As soon as the budget has been completed and approved, the stores department should obtain preliminary estimates of the material required for the work as outlined in the budget; also an estimated schedule of the time when such work is to be executed. This information enables the stores department to have the material on hand before the work is started, and to arrange the deliveries of material so that the stock balances will be kept to a minimum. In this connection, close contact must be maintained with the engineering department, in order that the stores department may be informed of any other contemplated construction work, or the cancellation of work which had been planned in the annual budget. The budget is particularly valuable for the scheduling of material orders which have to be placed on the Eastern markets. It is readily seen that the general storekeeper should be present at all meetings where plans for future developments or sales programs are discussed.

The quality and type of material required should be determined by the engineering and test departments and tabulated in a handbook of "Material Standards" and "Standard Construction Methods." This information will prevent different articles being carried in stock for the same purpose and also minimize the tendency of construction men to request non-standard material. Standardization means a reduction in purchases, a decrease of balances, less storage space, reduced handling costs and economy in accounting.

The Ordering of the Requisite Material

Correct requisitioning of material is the keynote to material control. This work often is regarded as a routine procedure and too much dependence should not be placed on the order clerk, who only has the stock card record as a guide and cannot be expected to be in touch with the entire organization or thoroughly know the physical property. It is therefore necessary that a copy of all material orders be furnished to the storekeeper, who checks them and notifies the order clerk if any substitution is possible, or if he has secondhand or old type of similar material in stock which should be issued. By experience it has been found that other departments can be induced to use such material when no new stock is available. Constant and persistent efforts along this line will result in the reduction of stock.

The requisitions for material should show all necessary information, such as quantity on hand, quantity due, unfilled orders, monthly consumption, additional quantity required, purpose of material, shipping instructions and a careful description of the material to be purchased. These requisitions should then be inspected and approved by the general storekeeper, who is responsible for the quantity of material to be carried in stock.

The Purchasing of Material

The purchasing department should assist in the control of material by buying standard material from reliable sources and by effecting deliveries so that the material will arrive on dates specified.

The purchasing department should maintain an efficient follow-up system, in order that the stores department may be kept informed regarding the progress of material shipments.

The Receiving, Storing and Issuance of Material

The receiving department should properly tag all material received and deliver it to the section storekeepers with the least possible delay. Written notification should be sent to the department superintendents upon the arrival of special material purchased for their department.

Adequate storage spaces, sectionalizing of the stock, standard methods of storage and the proper marking of bins, are of great value in the efficient control of material. One of the principal factors is the employment of experienced storekeepers and the training of employees in the performance of their duties.

The Salvaging of Material Returned to Stores

Material returned to the storeroom for salvage should not be allowed to accumulate. This work must be kept up to date and all material, except that which can be turned into standard items or that which is positively acceptable as substitutes, should be disposed of as is, or scrapped. Experience has demonstrated that the carrying charges are too high to salvage material, the probable use of which is questionable.

The Disposal of Obsolete, Excessive and Scrap Material

Due to the progress in the industry and the improvements in material, every public utility company has accumulated more or less obsolete equipment and material. As the storage space is constantly becoming more valuable and as the carrying charges are from 15 to 20 per cent, it is recommended that such obsolete material be immediately disposed of.

The responsibility for deciding what material shall be retained should rest with the general storekeeper, after consulting the department superintendents interested.

The fluctuations in the market price of scrap material are not so great but that it will be found advantageous to sell scrap each month, in order that the material and supply account may not be burdened with an excessive investment in scrap materials.

Conclusion

Storekeepers should not be handicapped by lack of co-operation from other departments. Department superintendents should realize that surplus stocks and obsolete material are costly and inefficient; that they are largely responsible for such conditions by overestimating their requirements, particularly when ordering special construction material or equipment.

Everything possible should be done to overcome the practice of maintaining large stocks of material for the purpose of meeting every possible emergency. Care must be used, however, not to lean backwards in the efforts toward reduction, as too small a stock will result in losses, due to misapplied labor and loss of revenue, due to inability to handle offered business.

Large stocks are usually caused by a natural, but unreasonable, demand of the user. Their view point is that labor or equipment should not be delayed awaiting material. This is easily understood; their primary responsibility is operation, but they fail to realize that surplus stocks are also very costly, not only in capital investment, but also in deterioration and obsolescence and often exceed the small loss incurred through delay in getting material. The stores department should impress on other departments that there is no conflict between a reduction of stock and in having what is wanted when it is wanted. The point is that a great deal more thought should be given the original order as to just what is required. In other words, real planning is necessary if stock is to be successfully controlled. Regardless of the amount invested in material, there will always be some shortage, so large stocks will not eliminate occasional delays.

Material control can only be made effective and successful by the recognition of the company executives that the stores department is an important department in the company organization, being responsible for the care and distribution of millions of dollars' worth of material and is worthy of their hearty support.

Fig. 1 (p. 407) illustrates the results obtained by the operation of a material control system as outlined in this report.

Surplus Materials*

By F. W. SMITH

The members of the Purchasing and Stores Section recommend that the work of the sub-committee on surplus materials be carried over until next year.

The reason for this recommendation is that this work is of such scope that it could not be given its due consideration up to this time. It is recommended that a central bureau be established through which the disposition of surplus materials can be handled. The importance of this work is sufficient, the section believes, to warrant a longer and more intensive study, and the establishment of such a bureau as above mentioned.

The functions of such a central bureau would be to receive lists of all surplus materials on hand from the various member companies. By an interchange of these lists, materials carried as surplus by one company would be found suitable for use of another company, and vice-versa, which would serve thus to reduce the surpluses among all member companies.

* **Report of sub-committee.—F. W. Smith, chairman.** C. R. Eccles, G. C. Robb, R. E. Thompson.

Inventories*

By WM. deWAARD

Past experience has proved that inventories not only are necessary in order that a proper check may be had between the amount actually invested in materials and the general ledger figures showing this tangible asset, but also to give an accurate check of the material itself and to compare the quantities on hand with stock card or stock ledger balances.

* **Report of sub-committee.—Wm. deWaard, chairman.** Wm. Maddock, I. B. Walther.

The two methods of inventory most commonly used are:

1. "The annual physical inventory"—by taking an actual count of the entire stock at the close of the fiscal period.

2. "The stock record inventory"—by segregating the entire stock into classes and taking a physical inventory of certain designated classes of material each month, arranging the work so that all material is inventoried at least one a year; checking the results obtained with the stock card or stock ledger balances and at the close of the year the annual inventory is then compiled from the balances as shown on the stock cards or stock ledgers.

The committee recommends "The annual physical inventory" method, for the following reasons:

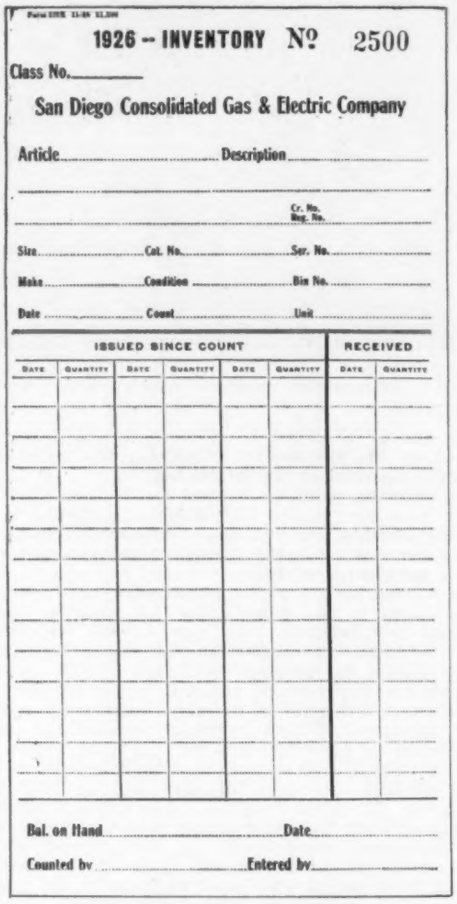
A. A more up-to-date actual count is obtained of the material on hand at the close of the fiscal period, because when using the stock record inevntory the date of the actual count is made at an average of six months prior to the accummulation of the inventory data.

B. The possibility of failing to inventory certain articles is minimized, as the counting and checking of the material can be carried on systematically from one end of the property to the other.

C. Less expensive, as it does not require a permanent inventory organization. It also saves reduction in traveling expenses for inventory crews to district storerooms.

D. The storeroom accounting work is not disrupted each month, as with the stock record inventory, where extreme care must be taken every inventory period that all entries of invoices, rceipts, credits, disbursements and itmes in process of manufacture, covering classes to be inventoried, are up to date, and that the time of final entries coincides with the closing of the monhtly inventories.

E. Least possible delay in storeroom operation and the conduct of business.



1926 -- INVENTORY No 2500

Class No._____

San Diego Consolidated Gas & Electric Company

Article..... Description.....

Cr. No.
Req. No.

Size..... Cat. No..... Ser. No.....

Make..... Condition..... Bin No.....

Date..... Count..... Unit.....

ISSUED SINCE COUNT						RECEIVED	
Date	Quantity	Date	Quantity	Date	Quantity	Date	Quantity

Bal. on Hand..... Date.....

Counted by..... Entered by.....

Fig. 1. An inventory form.

The committee further recommends the use of an inventory card, such as is shown in Fig. 1.

It also is recommended that in conjunction with the annual inventory, periodic physical inventories be made of the expensive classes of material which have a rapid turnover, such as commercial appliances, transformers, cable, wire, poles, crossarms and pipe. Copies of these periodic inventories, with information showing the quantities on order, should be furnished to the departmental scuperintendents interested. This will enable them to keep informed of the principal items of material available for immediate delivery.

It is further remommended that the procedure of the annual physical inventory work be the same as that so ably described in the report of the previous committee, under Subject No. 11, pages 165-6-7, of the 1925 P.C.E.A. Proceedings.

Stores Organization*

By F. F. HENRY

After thoroughly digesting the report of the committee handling this subject in 1925, it is this committee's opinion that "Stores Organization" has been covered in detail. Its recommendations as to personnel and division of responsibilities necessary to effect an efficient stores department appear to be such as would generally be applicable to the public utility companies represented in the purchasing and stores committee.

Compensation

The matter of greater compensation for stores department employees, to insure their continued employment with this department, is one worthy of serious consideration. It is the stores executives' contention that other departments are able to offer more wage to employees with stores department training, than is permitted to be paid in the stores department. Therefore promising talent is constantly released to these other departments, rather than to obstruct the employee's advancement.

The committee believes that it would not be impolitic to bring these conditions to the attention of the managements for their consideration.

* Report of sub-committee.—F. F. Henry, chairman. S. E. Hickman, R. E. Thompson, I. B. Walther.

Standardization and Simplification of Store Stocks*

By W. J. McCULLOUGH

Several of the public utility companies represented in the Pacific Coast Electrical Association during the past two years have made strenuous efforts to reduce their investments in materials, supplies and equipment, and this committee recommends that efforts should now be directed toward the standardization and simplification of store stocks.

The money value of the investments having been reduced to the minimum, it would appear that the elimination of duplicate and slow moving items would be a further means of effecting a stock reduction.

It is recommended:

1. That it is important to confine the material, supplies and equipment requirements of all departments to the minimum number of items.

2. That a catalog listing all materials, supplies and equipment be prepared by sections, or classes, showing the correct description, the section in which carried, the unit of measurement, etc.

3. That a catalog be provided for each department, or person, authorized to order materials, supplies and equipment.

4. That a committee representing the engineeering, operating, construction, purchasing and stores departments, be appointed to approve of the addition of any item to the catalog; such items to be considered only when recommended in writing by the department head. When requests are received for materials that are not now considered as standard, such requests should be submitted to the committee to determine its merits and various uses it can be put to and if adopted as standard, a written description is prepared specifying just what is wanted, and orders prepared for the purchasing department to call for bids.

5. When such additions displace an item previously adopted as standard, the committee should recommend disposiiton of the displaced item, i.e., whether the use of the displaced item should be continued until stock is exhausted, but no additional purchases made, or whether such displaced item should be disposed of by sale.

6. The list or catalog of standard materials, supplies and equipment adopted should be so complete as to supply practically the entire requirements of the company. Therefore, emergency-order purchases should be reduced to the minimum. It is a known fact that a great many of the special items referred to the material committee for disposition have been purchased on emergency orders and not used, or bought in excess of requirements and the excess stock returned to the general stores. Appreciating the importance of eliminating as many purchases by emergency orders as possible, it is recommended that an executive letter be sent to all department heads and district managers instructing that a letter explaining in detail the necessity for each emergency purchase, and that the emergency must justify the purchase, must accompany the record copy of the emergency order.

It is the opinion of this committee that a great saving can be made in the reduction of items carried; in the elimination of storage space, cost of handling, etc., and that these savings will justify larger stocks of standard materials, supplies and equipment being carried.

* Report of sub-committee.—W. J. McCullough, chairman. C. A. Kelley, D. P. Mason.

Stores Department Buildings, Facilities and Material Handling Devices*

By R. V. DODGE, JR.

The purpose of this paper is to enumerate the items generally governing the locating, constructing and equipping of yards and buildings for the stores department use.

Selection of Site

Beginning with the selection of the site, due consideration should be given to a study of motions or lost time by those required to draw or handle the materials, convenience being an important factor. In addition, the cost of the underlying real estate, the availability of railroad service, trucking facilities, material handling costs, and the cost of construction due to topographical peculiarities must be taken into account. Generally speaking, a level tract of land near the center of distribution is the most desirable.

Railroad Facilities

In the laying out of a storeyard, provisions must be made for sufficient and conveniently located railroad trackage. In the larger yards it often is most feasible to build a drill track or main lead from which the spur tracks or sidings may branch as required. For certain purposes, depressed or elevated tracks may facilitate loading or unloading operations.

Roadways

Much thought must be devoted to the location of roadways to gain maximum economy. These should be of ample width to avoid congestion and assure the easy handling of the equipment and materials.

Pavements

The necessity for improved pavements depends primarily on the soil characteristics. In some localities, roadways of natural earth answer all purposes sufficiently well or are made substantially serviceable with applications of gravel, screenings or cinders, with or without oil binders. In other places, more permanent pavements, such as Belgian blocks, macadam or asphaltic concretes or cement concretes are required. Steel re-inforcements and surface hardening may be desirable in the latter under severe operating conditions.

* Report of sub-committee.—Wm. Maddock, chairman. D. P. Mason, H. O. McKee.

Fences

Fences are generally demanded, not only to define the property lines, but to prevent trespassing and to protect the stock from theft. In many instances, wooden or barbed wire fences will fulfill the requirements. At other places woven wire or masonry are more satisfactory. Generally an appearance confroming with surrounging architecture controls the selection.

Gateways

Sufficient entrances should be provided. The gates may be of sliding, swinging, folding or lifting types. Always build the gates of generous width and, in using certain types having overhead construction, the proper vertical clearance should be determined.

Drainage

One thing that may be overlooked in planning the yard details is drainage. Slopes, gutters or valleys, catch basins, culverts and sewers should be designed to readily free the grounds of storm water.

Pipe Lines

Pipe lines should be placed underground, avoiding as far as practicable, installations under permanent structures. There should be water lines for ordinary purposes and fire protection, gas lines, compressed air lines, conduits for electric light and power wires, and telephones and perhaps oil lines. Where crossings under improved roadways or buildings are unavoidable, it is well to provide for future growth by laying pipes larger than actually required at the time or by providing extra ducts. In extensive installations, tunnels in which to run all pipe lines may be the most economical arrangement, all things considered.

Illumination

In arranging yard lighting systems, it is the best plan to have all wires underground in order that there may be no obstacles which will impede the operations of cranes. The flood system of illumination has been proved to be superior to a larger number of smaller units. It probably will be necessary to supplement the flood lights with local illumination at locations which are difficult to light.

Fire Protection

Insurance rates demand fire protection apparatus. Hydrants with hose and nozzles attached should be located at intervals sufficiently close to afford complete coverage. Usually 50 or 100-ft. lengths of hose are used and protection for the hose from the elements should be taken care of. It is well to use the same size of hose and fittings as are standard with the local fire department. If the pressure and volume available in the water supply system are insufficient it may be necessary to install water towers or pumping plants. Suitable chemical apparatus may be furnished. In arranging stocks of inflammable materials it is a good idea to space the piles so as to leave fire breaks or guards.

Oil and Explosives Storage

Special provisions must be made for the safe storage of oil products and explosives.

Incinerators

All storeyards of consequential magnitude should be equipped with incinerators properly designed. These provide means of disposing of rubbish and also can be utilized in salvage work.

Stores Buildings

Local demands will determine whether one building must house one or more of the stores department's functions. Stockrooms, warehouses, open storage sheds, oil and paint storage facilities, explosive magazines, salvage and reclamation shops, tool rooms, testing laboratories, offices, wash and locker rooms may be needed, and in some cases, pole treating or pipe wrapping plants and wood or metal working shops must be accommodated.

Sizes

The size of the buildings and the number of floors will be determined by studies of the physical properties and quantities of materials handled, accessibility and the handling required, the value of real estate and by the rate of growth of the community served.

Relative Elevations

Omitting reference to such engineering details as the sufficiency of foundations, dimensions of the structural members, etc., it is recommended that the stores department personnel be allowed to specify the desirable elevations of the main floors and leading platforms, clear ceiling heights, headroom under cranes, the advantages or disadvantages of balconies or mezzanine floors, and other items of this nature that clearly affect the performance of that department.

Class of Construction

In deciding upon the class of construction, many factors other than first cost are involved such as building restrictions, ordinances, fire hazards, earthquake risks, insurance cost, architectural beauty and maintenance expense. Large buildings may be of heavy wooden construction, known as the "mill type"; steel, brick, stone or tile, or re-inforced concrete; preferably the latter.

Floors

Data should be collected regarding the loadings of the various floor areas. The probable dead and live loads should be computed and the engineering department should be instructed to allow generous factors of safety to sustain the heavy concentrated weights that may occur. Frequently it may be desirable to design the structure to carry additional floors if vertical expansion is anticipated. Flood surfaces usually are made of wood, wooden blocks, compositions or concrete. Ease of trucking, fatigue of attendants and maintenance costs should be considered. In some buildings, perhaps, earth or graveled floors may serve the purpose.

Doorways

While there should be a sufficient number of doorways of adequate sizes, the fact that aisles and passageways leading to doors in excess of the actual requirements will reduce the net storage area must not be overlooked. The spacings should be practical, particularly where railroad cars are to be loaded or unloaded. In addition to freight doors, man doors are desirable. The selection of the type of door will depend largely on the size of the opening and the lighting requirements. The openings may be closed with steel curtains, swinging, sliding, or multi-section folding doors, operating either horizontally or vertically. Doors having fire retardant properties are desirable and generally required.

Sash

As a rule, storerooms are difficult to light on account of the bin arrangements. For this reason, as much daylight should be admitted as possible and from as many directions as possible. As much sash as can be used advantageously should be installed. Both wooden or steel frames may be employed, of either the fixed or the ventilating type, depending upon the type of construction. Thought should be given to the ease and safety of cleaning and, when out of reach, mechanical means of operating ventilators should be worked out. The kinds of glass desired should be specified—ordinary or plate, plain or wired, polished, rough, ribbed or other quality.

Roofs

It may not be proper for the stores department to say what style of roof shall be furnished, though the needs for skylights, or saw-toothed construction or special roof structures such as pent houses or tanks may influence the adoption. Flat roofs may be better for some localities and gabled roofs for others, truss dimensions, wind and snow loadings considered.

Stairways

Stairways in the multi-storied buildings must be provided, not only as desired for service, but as required by controlling ordinances. If two are built, they should be located as far apart as possible. The most suitable widths should be worked out and also the easiest "rise and run" dimensions. These may seriously affect satisfactory operation and accident prevention. The investigation should look to the elim-

ination of every possible fire trap, and an adequate number of fire escapes should be installed.

Elevators

A further step in multi-story construction will be the transporting of heavy materials, persons and possibly trucks, between floors by means of elevators. These may be manually or automatically controlled. Investigations should be conducted to decide between plunger or cable suspended types, based upon the advantages or disadvantages of overhead or underground parts, counterweights, speeds, etc.

Ramps

While it is possible to replace the elevators with ramps or inclines between the upper floors, these do not appear to be desirable except between the first floor and the basement, if any, on account of the length needed. If the main floor be at truck bed height, the ramp to the basement will be comparatively short. These ramps may be designed not only for industrial trucks but for the large trucks as well. In either case the minimum and maximum widths and gradients should be specified.

Hatchways

If the building be not equipped with either lareg elevators or ramps, it may be necessary to decide upon locations and sizes for hatchways through which transfers of materials between floors may be accomplished with cranes.

Marquises or Canopies

If the adopted construction does not include loading space for trucks within the building, then protection from the weather may demand marquises or canopies.

Vaults

Some classes of materials may be stored advantageously in vaults or separate rooms of fire-proofed construction, for which space must be allowed. Office records may, of necessity, be included in the contents of such vaults.

Refuse Chutes and Incinerators

Where combustible refuse will accumulate rapidly, refuse chutes and an incinerator may be incorporated in the building.

Pipe Lines

In planning the buildings, provisions for all the required pipe lines often are overlooked. Do not forget the hot and cold water lines, soil pipes and sewer connections, vent pipes, steam, gas and compressed air pipes, sprinkler mains, conduits for electric light and power wires, telephone cables, wires of signal systems and special requirements such as oil pipes, vacuum lines, tube systems, etc. Pipes may be exposed or run in chases or trenches. Such pipes as may require repairs should not be permanently concealed. Meters, traps and regulators may need special compartments.

Washrooms and Toilets

Washroom and toilet facilities also require much planning as to locations, sizes and equipment. The toilets, urinals, wash basins and sinks are the obvious equipment but shower baths, drinking fountains, water heaters and minor fixtures such as towel racks, soap containers, paper holders, waste receptacles, hand driers, mirrors, disinfectants, etc., should be arranged for as conditions warrant. The kind of partitions and stalls, wooden, metal, marble, slate, compositions or tile, should be selected with care. Tile appears to be the most desirable for the shower bath stalls, mainly for the psychological reasons, and for other stalls and the lower portions of the wall as well. The appointments and appearance of wash rooms reflect the policies of the company toward its employees. Floor drainage must not be left out.

Locker Rooms

It is the usual and recommended practice to furnish locker rooms for the workmen. Lockers may be of wood or steel, steel being greatly preferred for sanitary reasons. The sizes of the lockers should be governed by the occupations of the employees, some demanding more space than others. Benches and tables will increase the conveniences. If not elsewhere provided for, club or recreation rooms, dining rooms and perhaps sleeping quarters may be worth their costs by creating a good will and reducing labor turnover, but these are beyond the scope of this paper.

Lighting

The proper lighting of stores buildings does not always receive the attention which this important subject should be given. The intensities and spacings of units for the varying conditions should be worked out with the assistance of illuminating engineers, together with the selection of suitable types of fixtures for satisfactory diffusion and protection. The use of naked lamps should not be tolerated. Exterior illumination is usually required also. When laying out the wiring systems, be sure to provide for receptacles for portable lamps and appliances, also place the panels and switches in the most convenient locations.

Ventilation

Another more or less neglected feature is ventilation. Enough fresh air under the different conditions is essential for the maximum production involving either mental or physical efforts. The number of air changes for the purposes generally encountered have been worked out by the engineers of the manufacturers of blowers and are available. These could be studied and made applicable for all the stores department rooms. For example, the air in offices should be chnaged from six to twelve times an hour, that in toilets from twelve to twenty times. Natural ventilation cannot be depended upon as the weather conditions affect the air currents. When considering blower installations, the forced systems are better than exhaust fans because the latter may simply draw foul air from an adjoining space. The air in forced systems can be washed and filtered, cooled or heated and its humidity controlled.

Heating

All buildings in which continuous physical effort by the occupants is not required should be heated, even in such temperate climates as those of Southern California. Where a central steam supply is not within economic reach, furnaces, rather than stoves or salamanders, are required, either of the hot air, hot water or steam types. These may be gas, oil, wood, coal, briquet, or refuse-fired. Steam radiation may be either direct (through individual radiators) or indirect (by heating incoming air). The effects of temperature and humidity on both persons and the materials stored should be studied and proper control apparatus will result in economies. All the necessary flues and ventilating ducts should be taken care of in the building design.

Fire Protection

Fire retarding and fighting equipment almost always requires special provisions in the building plans. Automatic sprinklers are recommended and it is usual to place hydrants with hose and reels or holders at strategic points. High buildings may require water tanks or towers above the roof and may also have to be equipped with engine connections. If possible it is desirable to put in fire walls and stops. Temperature recording systems and alarms may be used. Chemical extinguishers are required in some localities and may avoid large losses. Fire escapes have been referred to in a preceding paragraph.

Oil Storage

The design of a workable system for the handling and storing of oil products presents many difficulties, due not only to their inflammable natures but to other inherent physical properties. Buildings or rooms housing them should be absolutely fire proof. It is the consensus of opinion that wherever possible storage tanks should be above ground, though local conditions may impose underground installations. The volumes handled and the reliability of the supply sources control the sizes. In the larger number of oil storage arrangements, pumping is unavoidable. Pumps may be hand-operated in very small systems, or power-driven. Under certain conditions pressure tanks and air lifts may be used. Other equipment

generally needed to handle profitably oils is filters, separators, drum driers and testing apparatus.

Bins and Shelving

The storekeeper perhaps is most concerned with the types and arrangement of bins, shelving and racks. Both steel and wood have advantages and disadvantages, but steel bins are accepted generally as being preferable, in spite of the initial cost, due to the flexibility, strength, utilization of space, appearance, ease of cleaning, and the lesser fire risk. Both open and closed types undoubtedly will be used, but if pracicable bins with divisions and backs of wire screening should be specified in order to better the lighting conditions. The need for drawer sections or cupboard sections with or without locks will have to be worked out for that particular stock. Ordinarily the best arrangements are to place the bins at right-angles to the walls or the main passageways. Heights of the bins will determine whether or not ladders or steps must be furnished.

Racks

Many articles lend themselves readily to storage in racks. Stocks of steel and iron shapes usually are stored horizontally, while conduit may be handled better vertically.

Counters

Counters with plenty of lobby space and working space behind should be provided and with sufficient length adequately to care for the rush periods. Space under the counters can be used to store small articles having the highest rates of turnover, as well as for measuring tools, wrapping paper, bags, etc. If the counters are built of wood, metal tops are desirable.

Screens

It it be necessary to keep unauthorized persons out of the stockroom (and usually it is) wire screens may be mounted on the counters. In most cases these need not extend to the ceiling. Wickets at the counter permit articles to be passed out. Gates with locks should be placed where they are deemed advisable.

Scales

Provision should be made for the installation of floor scales when planning foundations and floors. Of course, platform and counter scales should be available. Sizes of the platforms and capacities will be governed by the service. Scales may be of the dial or beam types, indicating, registering or counting.

Handling Devices

The question of material-handling devices for both yards and buildings is an extensive subject and only the more prominent features will be touched upon in this paper.

Cranes

Cranes always will be needed where heavy articles are stored. Numerous types on the market are suitable for the various services: overhead traveling cranes, trolley or monorail types, transfer cranes (which are combinations of the first two), gantry cranes, jib cranes, stiff-legged derricks and others. These may be hand, motor, hydraulic or air operated. Automotive cranes with electric motor or gasoline or steam engine drives are exceedingly useful in pole yards and on construction work. They may be of the tractor, truck or locomotive type, the latter requiring suitable trackage. Special rigging such as hooks, slings, buckets, loading magnets for the handling of scrap and pipe, and like contrivances can be adapted to crane work to speed and facilitate the work.

Conveyors

There are many other types of conveying and lifting apparatus from which to make selection: hand trucks, two or four-wheeled electric industrial trucks or tractors, with plain or lifting platforms, tiering or elevating machines (revolvators) and many special bins or racks on wheels or casters. Cranes are manufactured for the industrial tractors. If storage-battery trucks are to be used a charging outfit will be needed.

Loading and stacking conveyors, either of the roller, belt or bucket types, have their uses and elaborate systems may be evolved if warranted. Gravity chutes, dumb-waiters and tube systems may be desirable under certain conditions. Some materials may be moved with suction or blower apparatus. Just how many labor-saving devices to furnish is a problem in economics.

Miscellaneous Equipment

Measuring machines for wire and rope, sack cleaners and balers, vacuum cleaners, mopping machines, wire-tying machines, stencil cutters and embossing machines undoubtedly will save time. If much waste paper accumulates and there is a market for it a paper baler may be warranted. Sundry testing apparatus will be required some of which may affect the location and design of buildings. Signs, usually of enameled steel, are useful in warning of dangers and indicating directions. Directories may be needed in large buildings and bulletin boards are useful.

Offices

As a rule, certain enclosures must be made for office purposes. It is well to decide whether these shall be of permanent construction or movable partitions. The latter are recommended where rearrangements frequently are necessary. They may be of wood or metal and preferably in standard sections or sizes either with or without glass.

Office Equipment

In addition to the usual line of equipment, such as desks, tables, chairs, typewriters, adding and calculating machines, it is well to consider cabinets for stationery, office machines and records, portable or built-in safes, hat and cloak rooms or racks, lockers (if not provided for in locker room), clocks, automatic or intercommunicating telephones as well as city phone service. Where rooms are required for the switchboards of the automatic type they should be dust-proof; in storage battery room proper ventilation is important. There also must be means for charging of the batteries. Local signal circuits with bells or annunciators may save many steps.

Accoustical Treatments

In certain classes of construction, particularly concrete, accoustical conditions may prescribe the applications of sound-deadening materials to the ceilings and walls.

Blinds

Window blinds, shades or awnings will be needed because of exposure to sunlight and for privacy.

Power-Plant Equipment

In isolated locations where central sources of supply are not available provisions may have to be made for boilers, air compressors, pumps and other auxiliary apparatus.

Conclusion

In closing, it is desired to emphasize the thought that the foregoing subjects have not been treated exhaustively in this paper and that they should be expanded by adding other items as particular developments may prescribe, by sub-dividing and giving more minute details and by incorporating definite recommendations. The resulting treatise should be kept up-to-date continuously so that anyone, to whom the responsibility of preparing plans for improvements to stores facilities has been assigned, thus may have a complete outline for ready reference, guiding decisions and preventing the omission of vital considerations.

Transportation Section[1]

Shop Tools and Equipment*

The purpose of this paper is to discuss briefly shop tools and equipment and their merits, and to make certain recommendations.

Lathes

The principal purpose for installing a lathe in a shop is to take care of special jobs such as the construction of bushings, winch parts and parts of that nature that cannot be purchased from outside manufacturers; also to take care of special substation jobs and work for other departments. For auto repairs alone the purchase of a lathe hardly would be justified for the reason that most automobile repair parts may be secured from dealers and accessory concerns. However if a lathe is required, a 16-in. size appears to be the most suitable.

Drill Presses

The number of drill presses required in a shop is governed by the number of cars and trucks operated and the volume of work to be handled. Where only one drill press is needed, the type handling up to and including a 1-in. drill is recommended.

Radial Drills

From experience it has been found that this type of drill is required only where there is unusually heavy work to be done, such as power house and substation work.

Burning-in-Stands

The tendency among member companies generally has been to discontinue entirely the use of burning-in stands.

Regrinding, Reboring and Crankshaft Repairs

This work usually is sent out, as most of the member companies do not have sufficient regrinding and reboring work to justify the purchase of the special machinery required.

Emery Grinders

Emery grinders are necessary in every shop. The 6 to 8-in. size is considered large enough to handle most jobs.

Brake Relining Machines

Brake relining machines are essential only when there is a large amount of heavy work done and where there are no facilities for having brake work handled at local repair shops. The Petrie Brandt is recommended as giving the best results.

Dynamometers

This instrument is being experimented with extensively by the Pacific Gas and Electric Company and shortly they will be in a position to furnish a report as to its efficiency and economy in comparison with the present method of diagnosing car trouble.

Bench Tools

For valve refacers, the Quickway, and Black & Decker are recommended very highly. Bearing reamers and cutters, Green Ford special main bearing reamer (Fords only), Martell reamer for main bearings, Wishon connecting-rod reamer. For cylinder hones, the Hall Huttle may be used with good results. Piston and connecting rod liner: the Wishon is used by all with uniformly good service. Reamers: the Sioux, and Red Line are recommended.

Floor Tools

Engine stands of various makes and types are used by member companies. A homemade stand constructed of 1-in. pipe has proved satisfactory.

Two types of floor cranes are used. One is constructed with three wheels mounted on a triangular frame. The crane itself is of I-beam steel and is arched forward so that the upper end, supporting the block and tackle and hook, is suspended horizontally over the forward end of the base structure.

The other type of crane is equipped with four wheels, two each being mounted on 4 x 6-in. pine timbers. On each of these timbers are two legs of 4 x 4-in. pine, sloping up to an apex upon which is secured a 4 x 6-in. pine cross-piece from which the block and tackle is suspended. The purpose of this construction is to permit the crane to be maneuvered so as to straddle the particular piece of work being handled.

Cleaning and Painting Equipment

An efficient type of spray and engine cleaner is that which has an air compressor of 8-cu.-ft. capacity and develops a pressure of 125 lb. Several makes of motors and chassis cleaners are used by member companies and the most widely used is the Waterman-Greer steam cleaner. Others used and recommended are the Romart, which uses distillate; the Herco, which is an air-and-water cleaner; and the Kellogg high pressure water cleaner.

Painting

Villivas and Shelburn spray guns are recommended. In repainting cars the most common procedure is first to remove or strip the old paint, then wash with a coat of thinnner which is followed by a priming coat. This practice is followed usually if a car is to remain unpainted any length of time and tends to prevent rust and to neutralize any injurious acids.

Chain Blocks

It was agreed that the Yale chain block was the most practical type for general usage.

Battery Chargers

The Tungar charger is generally used by all and is conceded to be satisfactory.

Service and Grease Rack

Several types of grease racks are employed, mostly constructed of wood although some are of steel angle-iron. A rack constructed with the idea of conserving space is made flush with the floor and immediately over a pit thus permitting use of the space for other purposes when the rack is not in use. The elevated type of rack has the disadvantage of permanently occupying space that can be used for no other purpose. Furthermore in using this design of rack, time is lost in ascertaining that wheels are in the track before attempting to drive up on the structure. Extreme care must be taken always to strike the end bumpers easily so that the front wheels will not climb over.

Tire Tools and Equipment

Weaver tire tools are of a good grade and are used extensively. A few of the member companies are using vulcanizing outfits, but the majority has the work done by outside concerns.

Welding Outfits

Purox is considered the best.

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[1] **S. B. Shaw,** Pacific Gas and Electric Company, chairman. **P. H. Ducker,** Southern California Edison Company, vice-chairman. **J. M. Wainscoat,** San Joaquin Light & Power Corporation, secretary. **Executive Committee.—P. H. Ducker, D. P. Mason,** San Joaquin Light & Power Corporation. **C. D. Weiss,** San Diego Consolidated Gas & Electric Company. **E. C. Wood,** Pacific Gas and Electric Company. **General Personnel.—The California Oregon Power Company:** D. A. Runyard. **Coast Counties Gas & Electric Company:** A. E. Strong. **Coast Valleys Gas & Electric Company:** G. A. Peers. **Los Angeles Gas & Electric Corporation:** W. J. Schaeffer, **Pacific Gas and Electric Company:** E. C. Wood. **The Pacific Telephone and Telegraph Company:** O. R. Cole, V. W. Dennis. **San Diego Consolidated Gas & Electric Company:** L. A. Savage. **San Joaquin Light & Power Corporation:** J. S. Moulton. **Southern California Telephone Company:** W. M. Fairbanks. **The Southern Sierras Power Company:** C. H. Gray. **Western States Gas & Electric Company:** J. E. Kelley.

* **Report of sub-committee.—C. D. Weiss, chairman.** C. H. Gray, L. A. Savage.

Presses

For general garage work the 20-ton Weaver is most practical. For heavy duty work the 50-ton hydraulic press is recommended.

Portable Benches

Not being used by member companies.

Jacks and Dollies

The Red Devil and Weaver High Lift jacks are recommended. The Kempton rubber-tired dolly is used generally.

Creepers

Creepers are constructed of either wood or metal, but practically all are the same common design.

Tire Changers

The Weaver is recommended for garages where 50 or more cars are maintained. With fewer cars ordinary rim tools of cheaper design may be employed.

Precision Instruments

A set of micrometers is essential to any shop. Ames dowel gages also are necessary.

Wheel Pullers

The hub-type wheel puller is preferred to all others as it is by far the most efficient.

Wheel Aligners

The Bear Wheel Aligner is used extensively and is reported upon favorably.

Electric Test Stands

None of the member companies is using test stands. The initial expenditure is not justified by the amount of work to be done. It has been found more economical to send generator and armature work, etc., to outside electrical concerns for inspection and an estimate of repair costs. It can be determined then whether the article in question should be repaired or discarded.

Oil Filters*

The subject of lubrication has been treated fully in previous reports of this sub-committee. Therefore this discussion is limited to a study of the results obtained from the use of oil cleaners.

Practically all of the company operators are of the opinion that oil cleaners are a necessity, but have not sufficient data from an operating standpoint to justify their installation on all equipment. Most of the data secured has been from factory-equipped vehicles and these vehicles have not been in service for a period sufficient to determine how much the operating period before overhaul has been extended through their use. A large number of the factory-equipped cars use air cleaners which would have a tendency further to extend the period before overhaul, but how much has not been determined.

The oil filter with the replaceable filter unit usually is considered the most desirable on passenger vehicles as the unit is replaced on a certain fixed mileage basis. For truck use the self-cleaning type which may be cleaned without removing the filter unit is considered best for heavy equipment. Trucks frequently are in isolated localities for long periods and replacement units are not always available. With the use of a filter the oil is used for longer periods than without, but as the type usually used does not remove crank-case dilution there is a question as to the correctness of this procedure, especially on heavy equipment or where the vehicle makes a large number of starts. On passenger cars a 100-per-cent increase in mileage between oil changes appears to be satisfactory with a 25-per-cent increase for heavy equipment.

As cylinder oil accounts for only approximately 2 per cent of the total operating costs the saving in cylinder oil is very small compared with the saving in motor wear that will result from the use of clean oil.

Oil from several cars run under varying conditions and different mileages has been analyzed to determine the percentage of sediment remaining in the oil after passing a filter. The results are shown in Table I.

To determine the material removed from the motor oil by the use of oil filters, a filter unit of the removable type was secured and an analysis made. The deposit removed from the plates was 700 gm. or approximately 1½ lb. Of this amount 68 per cent was oil and 32 per cent was solid deposit. An analysis of this solid deposit showed carbon 87.74 per cent, iron 9.22 per cent and 3.04 per cent undetermined.

TABLE I—Sediment removed from oil filters.

	Miles	Motor Sediment per cent by Weight	Motor Sed. per cent by Volume
Car No. 1—White 2-ton truck	967	0.54	1.6
Car No. 2—White 2-ton truck	1,062	0.73	0.8
Car No. 3—*Dodge touring	2,682	0.87	2.6
Car No. 4—Dodge Roadster	1,000	0.71	2.2
Car No. 5—Ford touring	1,000	0.78	1.6
*This car also equipped with air cleaner.			
Samples were then taken from two cars without filters of any kind with the following results:			
Car No. 1—White 2-ton truck	250	0.40	1.0
Car No. 2—White 2-ton truck	500	1.82	4.5
The quantity of these samples was one quart each.			

This filter unit, which was installed at the factory, was removed from a touring car at the end of the first 10,000 miles traveled. It is considered that the iron deposit would be higher on a new or recently overhauled car than on the second 10,000 miles, but that the carbon deposit would be approximately the same.

One of the member companies has decided to install filters on all equipment. As these companies maintain accurate cost data, figures should be available in the near future to show whether filter installation is justified.

Power Devices*

When three men are able to leave a garage at eight o'clock in the morning with instructions to set three 40-ft. poles and return to the garage by eleven o'clock it indicates an advancement in the art of pole-line construction. In further consideration of this matter, if it is found necessary to dig the holes for these poles during that same period, the accomplishment is more interesting. All of this is absolutely possible with the use of power take-off devices applied to motor trucks.

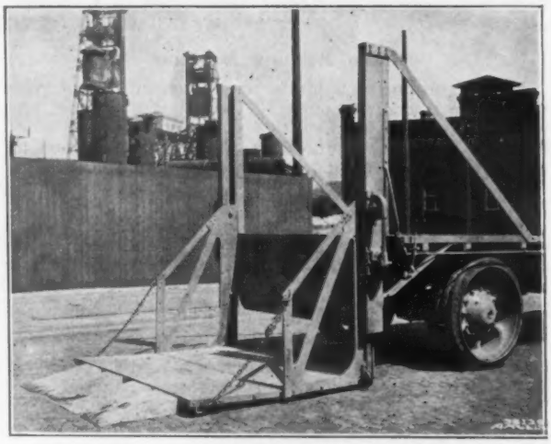


Fig. 1. Hydraulic-lift tail gate.

When the motor truck first was used by utility companies to replace horse-drawn wagons it was considered a great step in the reduction of costs because trucks were able to go from one place to another more rapidly and to carry greater loads with more speed. Shortly after the motor truck was placed in use some of the men conceived the idea of jacking up the rear end of the vehicle and using the wheels as nigger heads.

* Report of lubrication sub-committee.—V. W. Dennis, chairman. W. M. Fairbanks, D. A. Runyard.

* Report of sub-committee.—P. H. Ducker, chairman. G. A. Peers, W. J. Schaeffer, A. E. Strong.

However, this practice was much discouraged by the automotive operators for the reason that the construction of the gears was such as to not permit such abnormal use.

Demands continually arose for the use of some mechanical power to assist in handling heavy pieces of machinery, heavy poles and heavy wire with the result

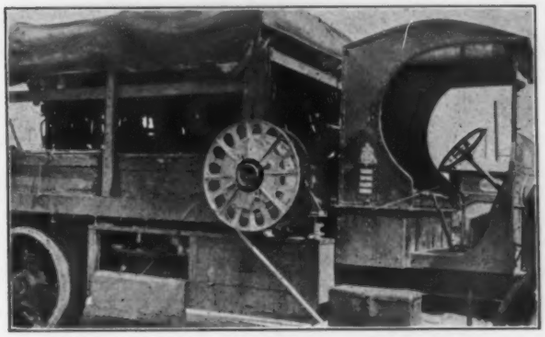


Fig. 2. Portable take-up reel.

that there was designed a power take-off applied to the transmission which would drive a standard winch. The The winch then could be set on the frame or body of the vehicle. In line with all other improvements of this type many modifications have been made so that today practically all of the large truck manufacturers are sending out as factory equipment motor vehicles having winches composed of reels and nigger heads.

Application of the winch to a motor vehicle encouraged the installation of a derrick that could be applied to the body of a truck and thus handle poles up to a length of 80 ft. Many companies have adopted the

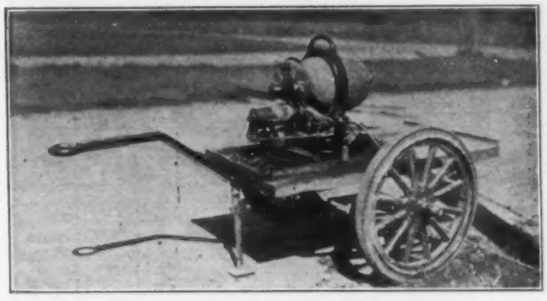


Fig. 3. Portable electric generator.

removable derrick made of steel tubing that can be taken apart and stored on the truck when not needed, thus allowing the truck to be normally free for operation as an ordinary line truck. Due to white ants, the line engineers have found it necessary to adopt a pole that had been treated for its entire length. While these full-treated poles were smaller in diameter they had been increased in weight. This fact has made it almost imperative for operating companies to furnish mechanical devices to crews erecting poles of this kind. Weight of transformers also has increased gradually. In short, it would be almost impossible, from an economic standpoint, to do away with the power devices.

It would be rather difficult to arrive at a definite figure as to the actual saving in money effected through the use of power devices over manual labor because of the fact that the apparatus has continued to change along with the motor vehicle. A direct comparison cannot be made. However, in cases where break-downs occur to power take-off devices serious delays are encountered. These, every superintendent will agree, speak for themselves as being costly and the power devices are repaired rapidly.

Many new applications for power devices gradually are coming into use and this committee believes that to describe all of the designs would result in too lengthy and uninteresting an article. It is recommended to all members developing new ideas along these lines to arrange to send them to the secretary of the Transportation Section that they may be filed and the information given out to each member as needed. Therefore only a few of the more recent developments will be mentioned.

A hydraulic-lift power tail-gate designed to lift 2½ tons from the ground to the level of the truck body is

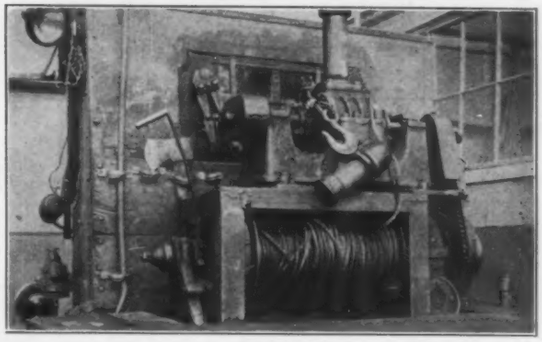


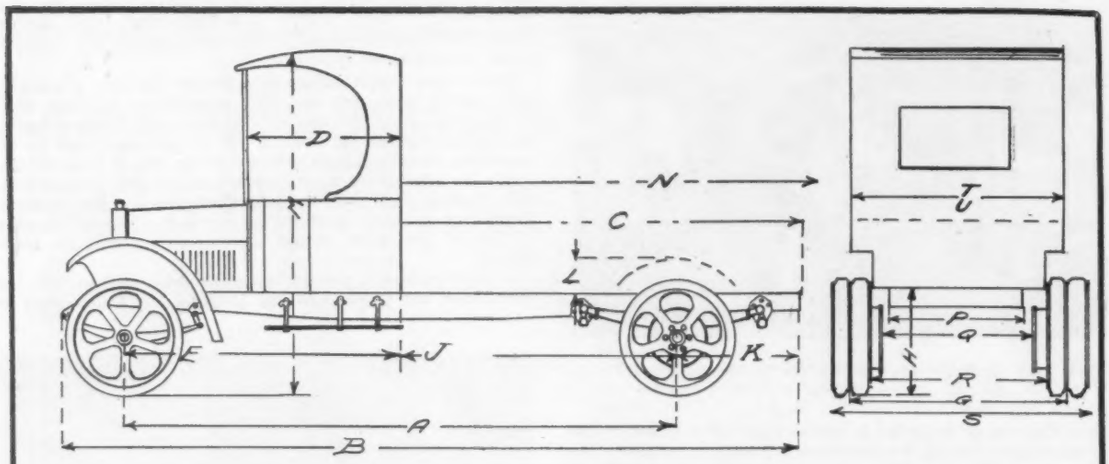
Fig. 4. Combined winch and suction pump.

shown in Fig. 1. Power for this is furnished by a hydraulic cylinder operated by a pump connected to the power take-off from the transmission. This equipment should prove of interest to those companies hauling material where it is necessary to receive the material from ground levels and to unload at ground levels.

A portable take-up reel which can be attached to the nigger-head on any type of horizontal winch is shown in Fig. 2. This has been found serviceable and satisfactory in the taking in of obsolete wiring and is particularly adaptable to telephone work.

A complete 110-lb. lighting unit mounted on a small 2-wheeled trailer or that can be handled on the truck by one man is shown in Fig. 3. This complete unit is made up of a small gasoline engine connected to a 500-watt, 110-volt, d.c. electric generator. This power is sufficient to operate two standard electric drills and can be of great service for jobs requiring rapid work in drilling pole steps or holes in crossarms either on the ground or in the air. This unit likewise is of value in providing emergency illumination on storm jobs.

A power winch mounted on a 5-ton truck is shown in Fig. 4. This winch is equipped with 1,500 ft. of ⅝-in. steel coupling. Connected to the winch is a 3-in. suction pump that may be used for handling either oil or water. This piece of equipment has been found to be efficient and satisfactory.



		The White Co		The Mack Co		Pacific Gas and Electric Co	San Francisco Gas and Electric Co	Coast Valleys Gas and Electric Co.	Coast Counties Gas and Electric Co	The Pacific Telephone & Telegraph Co				San Joaquin Light and Power Co	Southern California Telephone Company
A	Wheel Base.	145½	168	146½	164½	Variable	190	160	190	170½	174	168	158	180	164½
B	Total length of frame.	202	240	219½	243½	Variable	278	240	276	251½	267½	245½	235	256	243½
C	Length back of Cab.	107	146	120	144	144	164	136	165	146	164	107½	132 1/16	156	144
D	Dash to back of Cab.	45	45	44	45	44	47	40	46	45	45	45	39 9/16	46	44
E	Front Wheel to back of Cab.	75½	75½	73½	73½	Variable	88±	88	87	85½	67½	86±	83	82	73½
G	Rear Tread.	60 3/16	60 3/16	60½	60½	60	58 3/16	58	58 3/16	58 3/16	61 3/16	60 3/16	56	61	60½
H	Height of Frame at Rear Axle.	35	34½	32 7/16	32 7/16	Variable	34	30 Loaded	42	32 Loaded	34 Loaded	32 Loaded	31 3/16	39	34 7/16
I	Clearance.	9	9	13½	13½	Variable	8¾	11					8 3/16	11½	10½
J	Back of Cab To Back of Rear Axle.	70	92½	73	91	91	100±	74	94	84 3/16	106½	82	74 1/16	101	91
K	Back of Rear Axle to back of Frame.	37½	53½	47	53	53	62	48	64	61½	57½	25½	57 1/16	55	53
L	Clearance above Wheels.	12" Frame	12" Frame	18" Loaded	18" Loaded	Variable	18½	6	12	12	12	12	13½	7	7
M	Total Height of Cab.			93½	93½	82	94	94	98 3/16	98 3/16	100 3/16	98 3/16		96	96
N	Maximum Body length.	119½	158	132	162	144	164	144	168			146	84	156	144
O	Width of Channel Frame.	2 3/16	2 3/16	2½	2½	Variable	3 1/16	3 1/16	2½	2¾	3½	2½		2½	2½
P	Width of Chassis	34	34	33½	33½	34	34	34	34	34	42 7/16	34	34	34	33½
Q	C of C Springs	39½	39½	40½	40½	Variable	41	40	54	40	39	39½		40	40½
R	Width inside of Wheels	63½	63½	50 9/16	50 9/16	Variable	51	52		52	50	54½		53	51 7/16
S	Ex. Frame Width of Wheels.	70½	70½	74 7/16	74 9/16	Variable	84	68	66	73	73 9/16	70	66 7/16	72	74 3/16
T	Ex. Frame Width of Body.	78	78	60½	60½	78	96	78	76	70		70	56	77	72
U	Ex. Frame Width of Cab.	49	49	56½	56½	54	50	52	47	48		48	36	44	48

Make	White 20	White 20	Mack	Mack		White	Graham	White	White 51	White 50	White 20	Graham	Mack	Mack
Capacity	2 Ton	2 Ton	4B 2 Ton	4B 2 Ton		2½ Ton	1½ Ton	2½ Ton	2½ Ton	3½ Ton	2 Ton	1½ Ton	2 Ton	4B 2 Ton
Work performed by Unit						Line Const.	Line Const.	Line Const.	Line Const.	Heavy Hauling and Underground	Line Const.	Light Const. Work	Line Const.	Const. Work
Load of Unit						8000	Variable	5 Ton	2 Ton	5½ Ton	1½-2 Ton	1½ Ton	2 Ton	5 Ton
Miles per day or Length of haul						Max 75 Miles	Variable	Variable	13 Miles	85 Miles	15 Miles	25 Miles	Variable	
Type of Body						Special		Special Dump	Special Stake	Open Stake	Special Platform	Stakes		Stake Contr.
Weight of Chassis	4465	4680	5900	5900		7500		7400	7100	8130	74	3170		6050
Front.	2099	2200	2960	3070					3290	3740		1565		2960
Rear.	2366	2480	2940	2830					3810	4390		1605		3070
Per cent Front.	47	47	51	52					44	46		51 3/16		49
Per Cent Rear.	53	53	49	48					56	54		48½		51
Body Allowance	1500	1500	1500	1500		2200	1000	2000	1800	2000		1000		1500
LOAD DISTRIBUTION												3000		5000
Total Weight	12000	13000	11300	11400		9700	8020		16200	18100		7170		
Front.	3120	3510	4180	4340		2522	2280		4000	5250				3315
Rear.	8880	9490	7120	7060		7178	5740		12000	12850				3685
Per Cent Front.	26	27	37	38		26	28		25	29				27
Per cent Rear.	74	73	63½	62		74	72		75	71				73

Fig. 1. Data on 2-ton truck.

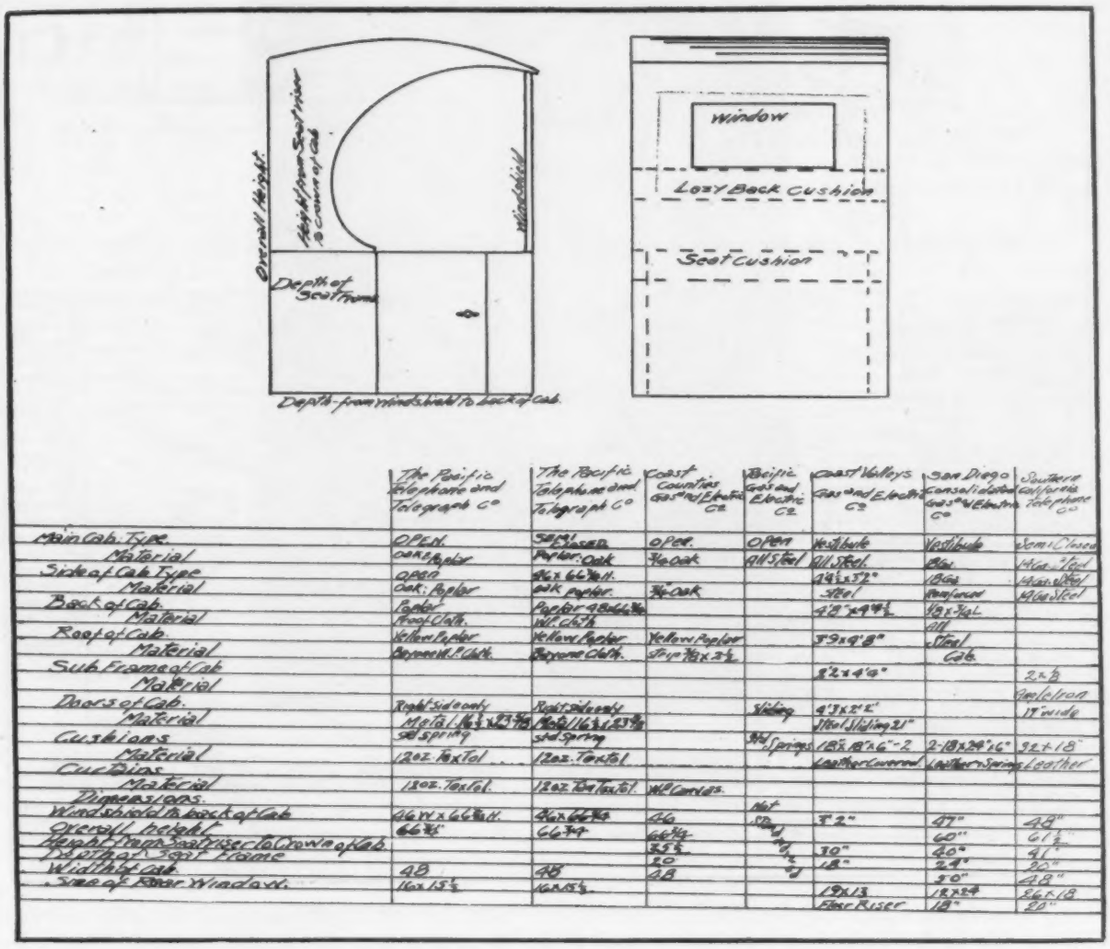
Vehicle and Body Design*

With the development of the motor truck the engineer is confronted with the problem of operating efficiency and the standardization of equipment. The standardized, efficient unit for electrical cnostruction and maintenance must have a large scope of operation. A survey of the operating field shows that the points to be considered are the topographical conditions of the section; the line units such as line construction, service hook-up, transformer installation, etc.; and adequate auxiliary equipment to handle this phase efficiently.

The 2-ton unit for electrical construction and maintenance is shown in Fig. 1. The underground unit must be equipped to handle cable pulling, junction box installation, transformers, etc. The unit must be equipped with facilities that will permit it to be transferred from one department to another and capable of performing any of the duties efficiently and economically. The vehicle stock (parts used) weight must be within an efficiency limit; the load and speed and horsepower all must come within the efficiency limit. The body design that will cover this scope of work will have to be of the compartment type with a canopy top. The compartments and boxes are a side installation with the compartments utilizing the space between the frame and bed. The construction above deck is the outboard fitting boxes, derricks and boom compartments, and rope and wire racks. This installation is made on the side stanchions. The ladder racks are placed on the outside of the body on the right-hand or sidewalk side. The top bows fit in sockets and are removable so the top material may be rolled back any distance, converting it into an open body. The tail gate is equipped with a vise and acts as a bench.

The winch is mounted in back of the seat with niggerheads that can be extended through an outboard bearing and a splined socket, making them removable when not in operation. The pull is through snatch blocks and can be operated from either the front or rear.

In considering the body design the total body allowance on the 2-ton unit is 1,500 lb. and divided into 400 lb. front and 1,100 lb. rear. The cab design and construction are of the all-steel type, semi-closed with a seating capacity of three men.



	The Pacific Telephone and Telegraph Co	The Pacific Telephone and Telegraph Co	Coast Counties Gas and Electric Co	Pacific Gas and Electric Co	Coast Valleys Gas and Electric Co	San Diego Consolidated Gas and Electric Co	Southern California Telephone Co
Main Cab. Type	OPEN	Semi Closed	OPEN	OPEN	Vestibule	Vestibule	Semi Closed
Material	OAK & Poplar	Poplar Oak	¾ Oak	All Steel	All Steel	Gas	Main Steel
Side of Cab Type	OPEN	46 x 66 ¾ H.			24½ x 32"	Gas	Main Steel
Material	Oak. Poplar	Oak poplar	¾" Oak		Steel	Panelwood	Main Steel
Back of Cab	Open	Poplar 48 x 66 ¾			48" x 94½	1/8 x 3/4 L	
Material	Roof Cloth	Wt. Cloth				All	
Roof of Cab	Yellow Poplar	Yellow Poplar	Yellow Poplar		59 x 98"	Steel	
Material	Bayonne M. P. Cloth	Bayonne Cloth	Strip 78 x 3½			Cab	
Sub Frame of Cab					82 x 46"		2 x 6
Material							Reinforced
Doors of Cab	Right side only	Right side only		Sliding	43 x 82"		17" wide
Material	Metal No 3 x 27 ¾	Metal 16 x 23 ¾			Steel Sliding 21"		
Cushions	Coil Spring	Coil Spring		Hair Springs	18 x 18 x 6" - 2	2-18 x 24 x 6"	92 x 18
Material	12 oz. Tex Tol	12 oz. Tex Tol			Leather Covered	Leather Springs	Leather
Curtains							
Material	18 oz. Tex Tol	18 oz. Tex Tex Tol	Wt Canvas				
Dimensions							
Windshield to back of Cab	46 W x 66 ¾ H.	46 x 66 ¾	46	Not Shown	52"	47"	48"
Overall height	66 ¾"	66 ¾	66 ¾			60"	61½"
Height from Seat Riser to Crown of Cab			35½		30"	40"	41"
Depth of Seat Frame			20		18"	24"	22"
Width of Cab	48	48	48			30"	48"
Size of Rear Windows	16 x 15½	16 x 15½			15 x 13	18 x 24	Each 18
					Floor Riser	18"	20"

Fig. 2. Data on truck cab.

With the flexibility of this unit in its operations and with the motive of efficiency in operation, the consideration of the factor of safety, depreciation, load distribution, cost per mile and district topography, the following data of some of the important dimensions will be of interest in designing a unit of this type. (See Fig. 1 for data.)

The weight-allowance limits and percentages of the unit are as follows: Total weight of chassis, 5,900 lb.; front, 3,070 lb.; rear, 2,830 lb.; per cent front, 52 per cent, and rear, 48 per cent. Total body allowance, 1,500 lb.; front, 400 lb.; rear, 1,100 lb.; front, 27 per cent, and rear, 73 per cent. Total load allowance, 4,000 lb.; front, 1,065 lb.; rear, 2,935 lb.; front, 27 per cent, and rear, 73

* Report of sub-committee.—E C. Wood, O. R. Cole.

per cent. Total chassis weight, 11,400 lb.; distributed, front, 4,340 lb., and rear, 7,060 lb.; front, 38 per cent, and rear, 62 per cent.

The Truck Cab

The type of cab that is of favor on the heavy and medium weight equipment is the semi-closed type shown in Fig. 2. The material seems to be equally divided between the all-steel-type and the wooden type cab. In the all-steel cab the material ranges from 14 to 18 gage. In the wooden type the general specifications are oak for supporting members and poplar for minor supports. For top-covering material, 12 oz. Textol seems a favorite. Rear-vision window dimensions range from 12 x 15 to 26 x 18 in.

Taking into consideration the cabs used by the light and telephone companies of California the average standard cab would have the following specifications:

Main cab vestibule, all-steel, 16 gage.

Sides of cab, 46 in. wide, 66¾ in. high, reinforced steel, reinforcement, 2 x ⅛-in. angle-iron.

Back of cab, 48 x 66¾-in. 16-gage material.

Roof of cab, 16-gage material.

Sub-frame, angle-iron, 20 in. wide, 20 in. high.

Doors, metal, 17 x 23⅝ in. with sliding windows.

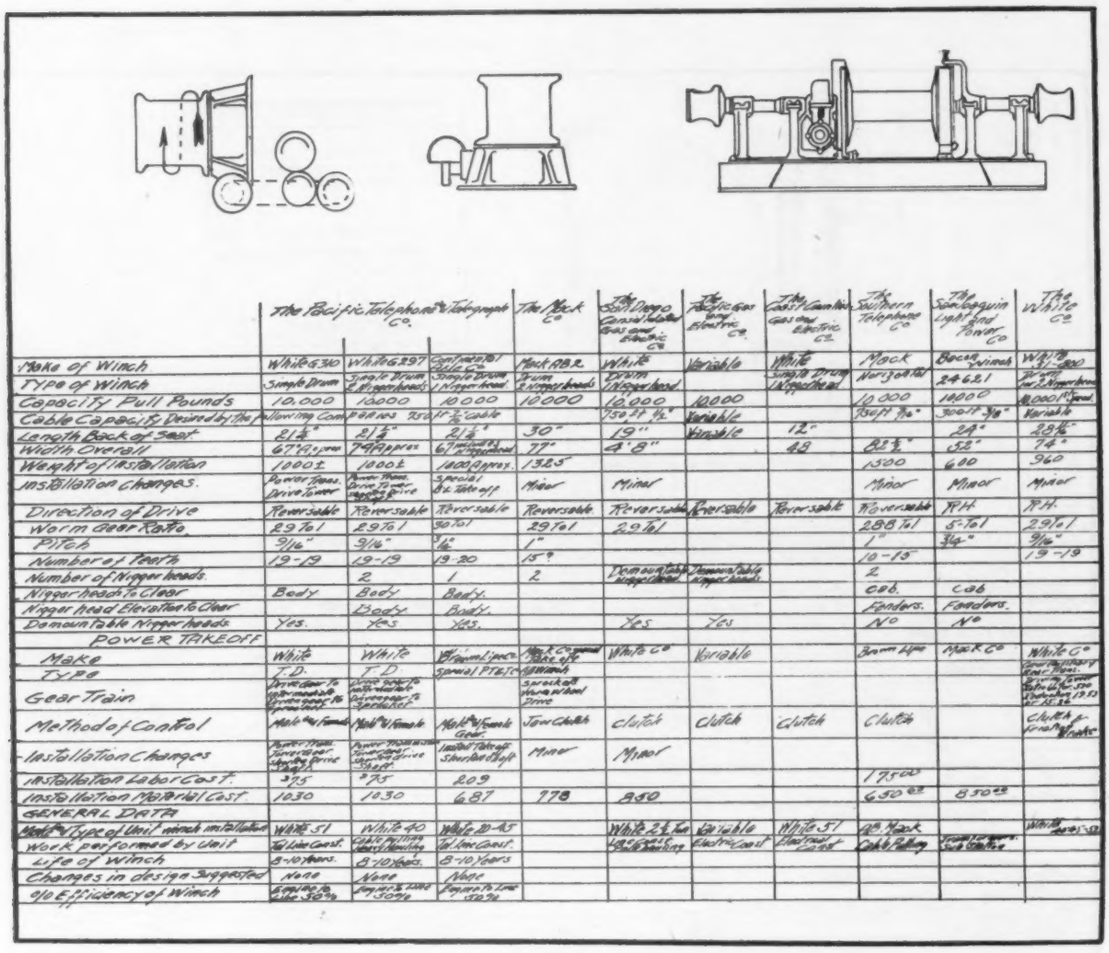
Cushions, two, 18 x 24 in. x 6 ft. Springs and leather covered.

Height from seat riser to crown of cab, 46¾ in.

Size of rear-vision window, 16 x 15½ in.

The unit of preference seems to be the single-drum winch with either one or two nigger-heads as shown in Fig. 3. This winch will take care of the majority of problems and is quite universal among the companies. Where the unit is designed for a special application, the field of auxiliary units is so numerous and their application so varied that it constitutes a special analysis of the work in order to obtain efficiency.

The demountable nigger-head has become a favorite for accessibility in handling many outboard problems such as winding cable, angular pulling, light pulling any many other pulling and hoisting jobs. This has proved quite efficient and very accessible.



	The Pacific Telephone & Telegraph Co.			The Mack Co	The San Diego Consolidated Gas and Electric Co	The Pacific Gas and Electric Co.	The California Gas and Electric Co.	The Southern Telephone Co	The Saint Laguin Light and Power Co	The White Co.
Make of Winch	White 6330	White 6297	Confidential	Mack A.B.R.	White	Variable	White	Mack	Bacon Equipment	White
Type of Winch	Single Drum	Single Drum 2 Nigger heads	Single Drum 1 Nigger head	Drum 2 nigger heads	Drum 1 nigger head		Single Drum 1 Nigger head	Nor 3 or 4 Tol	24621	
Capacity Pull Pounds	10,000	10000	10000	10000	10,000	10000		10,000	10000	8,000 Pound
Cable Capacity Desired by the following Com	800 ft 7/8	750 ft 7/8	1000 ft 7/8 Cable		750 ft 7/8	Variable		1500 ft 7/8"	3000 ft 3/4"	Variable
Length Back of Seat	21½"	21½"	21½"	30"	19"	Variable	12"		24"	23½"
Width Overall	67½ inches	74 Approx	67 Inches Approximated	77"	4'8"		48	82½"	52"	74"
Weight of Installation	1000#	1000#	1000 Approx.	1325				1300	600	960
Installation Changes	Power Take-off Drive Counter	Power Take-off Drive Counter Shaft Drive	Special Pto Take off	Minor	Minor			Minor	Minor	Minor
Direction of Drive	Reversable	Reversable	Reversable	Reversable	Reversable	Reversable	Reversable	Reversable	R.H.	R.H.
Worm Gear Ratio	29 to 1	29 to 1	30 to 1	29 to 1	29 to 1			288 to 1	5 to 1	29 to 1
Pitch	9/16"	9/16"	9/16"	1"				1"	3/4"	9/16"
Number of Teeth	19-19	19-19	19-20	15				10-19		19-19
Number of Nigger heads		2	1	2	Demountable nigger head	Demountable nigger heads		2		
Nigger heads To Clear	Body	Body	Body					Cab	Cab	
Nigger head Elevation to Clear		Body	Body					Fenders	Fenders	
Demountable Nigger heads	Yes	Yes	Yes		Yes	Yes		No	No	
POWER TAKEOFF										
Make	White	White	Warner Lipe	Mack Co Special Mack Pto	White Co	Variable		Warner Lipe	Mack Co	White Co
Type	T.D.	T.D.	Special PTO	Allmetal Sprocket Inboard Drive						
Gear Train	Drive Gear to Intermediate Gear to Pto Shaft	Drive Gear to Intermediate Gear to Pto Shaft								
Method of Control	Male & Female	Male & Female	Male & Female Cone	Jaw Clutch	clutch	clutch	clutch	Clutch		Clutch
Installation Changes	Power Take-off Drive Counter Shaft Drive	Power Take-off Drive Counter Shaft Drive	Install Take-off Same as Shaft	Minor	Minor					
Installation Labor Cost	375	375	209					175 00		
Installation Material Cost	1030	1030	687	778	850			650 00	850 00	
GENERAL DATA										
Make & Type of Unit which installation	White 51	White 40	White 12-A5		White 2½ ton Special Purpose Truck	Variable Electric Cost	White 51 Standard Cab	Mack	Cable Pulling	White
Work performed by Unit	Line Const.	Cable Pulling Heavy Handling	Line Const.					Cable Pulling		
Life of Winch	8-10 Years	8-10 Years	8-10 Years							
Changes in design Suggested	None	None	None							
% Efficiency of Winch	Equal to Cable Strength	Equal to Cable Strength	Equal to Cable Strength							

Fig. 3. Data on winch and capstan as used in construction work.

As a standard, with consideration to the field of usefulness, built from data compiled from the California companies, the following will meet their specifications except in special equipment:

Winch type, single-drum with one or two niggerheads.

Pull, 10,000 lb. in low speed.

Drive, reversible.

Brakes, friction and safety pawl.

Cable capacity, variable lengths and sizes.

The standard makes on the market meet the above requirements and the gear ratios and power take-off all are within a minor ratio of each other. In these specifications the range of pull and weight are proportional for a 2-ton unit. The capstan is desired for units of special application such as trouble cars of lighter capacity.

What Has the Northwest Been Doing During the Passing Year?

By D. C. Green

President, Northwest Electric Light and Power Association; Northwest Division, National Electric Light Association

AS AN industry we are not concerned with psycho-analysis, which seems to be a present day fad in colleges, on lecture platforms and in the criminal courts. But it has recently occurred to me that it would be a very interesting — a very educational thing if we could at least perform one experiment along this line; I mean if we could detach ourselves from all ordinary personal and corporeal and corporate liaisons and stand off on the sidelines and observe ourselves and our enterprises with a studious and far-seeing eye.

D. C. GREEN

It would be somewhat like looking upon the silver screen and seeing a slow motion picture. We might see, perhaps, perfection of form in one part of our performance, while in others there might be a touch of the ludicrous, the clumsy and the haphazard. We would be able to see things as they are, at least. We would know if our stance, our approach, our stroke and our follow-through were leading to a creditable score or one we would not talk about at luncheon the next day.

We move so swiftly in this industry, however, that the opportunity for such study is not presented. It is a cheering—an inspiring thing nevertheless to know that there is, perhaps, not another industry in the world operating in its many, many fields with even comparable efficiency.

During the passing year progress and development in the Northwest has been marked. The sessions of the forthcoming June convention of the Northwest Electric Light and Power Association will demonstrate this. The technical, accounting and commercial sections have met and I know that their studies and conclusions will prove of intense interest to the delegates attending.

Now, why conventions?

Conventions should not partake of the characteristics of the hum-drum of a laboratory and lecture room. The essence of much profound study is presented, and if a delegate leaves the conventaion with a single constructive new idea to take back to his desk at home he is well repaid for his attendance at the convention.

In planning the 1927 convention of the association this has been the thought. Men of nationwide reputation will address the sessions and their presentation will be of real worth to all who are striving for greater efficiency in this industry that is so close-knit with the fortunes of all people in all walks of life, of all industries and activities in greatly diversified fields. The sessions will consume only the forenoons, and yet it is sensed that entirely adequate time is afforded to assimilate the matters that will come before the delegates and also permit the sections to cover completely all their own special problems.

To discover our faults and improve our methods will be the foundation on which we build this convention. To seek a way to discard technicalities which the public does not understand and to establish more satisfactory public relations by making it possible for the public to understand more concerning the character and functioning of our business will be a major subject. To have the public see our industry in its true light will be wholesome and profitable.

Just a word now concerning the convention city for 1927—Salt Lake City. It sits in queenly dignity in a beautiful valley rimmed by towering mountains wearing perpetually a crown of glistening snow. The city is the busy commercial, industrial and social capital of the vast Intermountain Empire. It is the gateway to the scenic wonderlands of the West. Its opportunities for recreations and pleasures are offered without sint. You will be happy here.

Commercial Section Committee Reports

Executive*

This committee held meetings in Portland in October, 1926, and February, 1927, at which the general work of the section was discussed and planned. We have to report a most successful mid-winter meting of the section held in Portland, Feb. 7 and 8, 1927, at the Multnomah Hotel, which meeting enjoyed a large attendance with very good representation from all districts served by the Section. Preliminary committee reports were submitted by chairmen of the various committees and full discussion on all of the subjects covered was had. A complete report of this meeting has been turned over to the associtaion secretary for the permanent files of the association.

The committee has studied carefullly the operations of the Commercial Section and is convinced that tremendous loss of time can be eliminated in the work of the section and consequently greater benefit will accrue to the industry if the Commercial Section is completly reorganized. Under present operating conditions from the time when committees are finally appointed after the annual meeting until the completed committee reports for the June convention must be filed for printing barely six months have elapsed. The committee believes this condition should be remedied and at the same time that the section can be so organized as to permit continuous progress of activities over any number of years with experienced committeemen in the saddle at all times. The committee believes this can be accomplished by the adoption of the following organization plan which we recommend for earnest consideration:

Organization

Section Chairman.—If the work of the section is to go on from year to year, smoothly and continuously, and without a long pause immediately following the annual convention, it is highly desirable that the incoming chairman shall be a man who has been active in responsible work of the section during the previous year and who knows in advance that he is to have the responsibility of formnig the new section immediately after the annual convention.

Section Vice-Chairman.—Immediately after receiving his appointment from the incoming president of the Northwest Electric Light and Power Association, the section chairman should, in conference with the prospective president for the following year, select a vice-chairman for the section, with the understanding and intent that this vice-chairman should succeed to the section chairmanship one year later.

Section Executive Committee and Bureau Chiarmen.—The chiarman and vice-chairman shall then appoint three bureau chairmen who with themselves shall constitute the Executive Committee.

Bureau Vice-Chairmen.—The chairmen of these three bureaus in consultation with the vice-chairman of the section shall each select a vice-chairman for his bureau, with the understanding that these vice-chairmen will automatically be appointed the following year to the new executive committee and will become chairmen of their respective bureaus.

Committees.—Committees under each bureau need not necessarily be the same from year to year but should vary in accordance with variations in the problems confronting the industry at the time.

The number and kind of committees to function during the year and the problems which they are to study or work upon should be determined at the first meeting of the new executive committee, at which vice-chairmen of the bureaus should also be present.

All of this preliminary organization and planning can and should be done at the Northwest Electric Light and Power Association annual convention when the personnel of the men who are to have the responsibility of carrying on is known in advance. The meeting at which these appointments are made should be held at the close of the last session of the Commercial Section at the convention.

Having determined the committees to be appointed, the bureau chairmen, with the approval of the section chairman can then select the committee chairmen and personnel, which should be completed and reported to the association secretary within thirty days after the convention, whereupon the work of the new year will be in full swing.

Meetings.—Bureau and committee chairmen and vice-chairmen should attend all meetings called by the section chairman and unless they are in a position to do so they should not be appointed or accept appointments as such. Unless committee men and chairmen can participate actively, they should not be appointed or should not accept appointments for these positions. It should be the duty and practice of the appointing officer to make this clear at the time of selecting and notifying his appointees that attendance at these interim meetings is essential.

Duties of Bureau Chairmen.—Details of the work of the several committees shall be worked out under the sole direction and responsibility of the respective bureau chairmen.

Duties of Section Executive Committee.—Budget allowances, matters of policy and the general plan of the year's work, including dates and locations of meetings shall be worked out by the executive committee of the section under the guidance of the section chairman.

Papers and Programs.—Papers and programs presented at the annual meeting shall be selected by the executive committee.

* **G. C. Sawyer,** Pacific Power & Light Company, chairman. **Eastern Oregon Light & Power Company:** E. L. Crockatt. **Idaho Power Company:** J. F. Orr. **Northwestern Electric Company:** J. C. Plankinton. **Pacific Power & Light Company:** B. P. Bailey, V. H. Moon. **Portland Electric Power Company:** A. C. McMicken, F. H. Murphy. **Puget Sound Power & Light Company:** R. W. Clark, L. R. Grant. **Utah Power & Light Company:** R. M. Bleak. **The Washington Water Power Company:** L. A. Lewis.

Commercial Cooking*

The committee appointed to report on commercial cooking for the Northwest Electric Light & Power Association for the year 1927 has followed the suggestion by the national committee of dividing the report into the following divisions:

1. Desirability of commercial cooking load to central station.
2. Relative importance of load.
3. Possibility of increased power sales.
4. Load characteristics.
5. Present development.
6. Typical experiences of central stations in developing this load.
7. Endorsement of central station executives.
8. Advantages to the user.
9. Feature sales plan.
10. Construction and durability of equipment.
11. Data on application cost and savings.
12. Necessity for careful estimations of current consumption, first cost of equipment and wiring costs.
13. Rates.
14. Load factor.

* **J. C. Plankinton,** Northwestern Electric Company, chairman. **Edison Electric Appliance Company:** R. J. Cordiner. **Northwestern Electric Company:** R. W. Faville. **Utah Power & Light Company:** H. M. Ferguson. **The Washington Water Power Company:** Carl L. Hoffman.

Desirability of Commercial Cooking Load to Central Station

The committee feels that this type of load is a very desirable load for the central station to develop. A great deal of printed matter and discussion has been presented setting forth its desirability. Briefly, we would just say that commercial cooking and baking equipment offers the central station a load possessing unity power factor, relatively high load factor, and at the same time a load having a comparatively low demand.

Due to the characteristics of the operation of this load, we find that the sale of kilowatt-hours may be increased with very little capital expenditure on the part of the central station covering distribution costs, generation, etc. This is due mainly to the fact that this type of load is virtually an off-peak load. For example, the restaurant and allied trades utilizing electric ranges and hot plates for the major part of their cooking, do their cooking in the early morning hours and rarely after 4:30 a. m. This class of trade operates seven days a week and for thirty days each month. The bakery trade ultilizes this service late at night for the larger consumer, and for the small retail merchant the hours of operation are from 5 a. m. to 11 a. m. We find, therefore, that the commercial appliances fill in the valley of the system load curves, and are not operated upon the system peak.

Relative Importance of Load

The importance of this load as compared to other types of load cannot be overlooked, since we find that its load factor compares very favorably with other types of load and also its diversity, we believe, will be high. It has been found universally throughout the country, that different types of cooking require various wattage capacities per person per meal. By that we mean that the American plan of cooking, such as is employed by hospitals, institutions or cafeterias, averages from 350 to 400 watts per preson per meal. European type cooking such as is employed in restaurants and hotels where a large amount of short order cooking is done requires from 400 to 500 watts of cooking capacity per person per meal. The small bakery uses approximately 150 kw-hr. per kw. installed, while the larger bakery uses from 160 kw-hr. to 263 kw-hr. per kw. of equipment installed, and further it requires approximately 90 watts of cooking capacity per pound of baked goods. Knowing your rate per kw-hr. you would be able to arrive at the yearly return for each kilowatt of capacity installed in either small or large bakery, and these returns, we believe, will compare favorably with that of other types of load. Restaurants and allied trades, we believe, will show approximately the same number of hours use of demand as is given above for the small and large bakery.

Possibility of Increased Power Sales

There is, without a doubt, a potential field for the sale and promotion of commercial appliances in the Pacific Northwest. In the city of Portland a canvass was made of 102 restaurant and hotel customers, disclosing the following equipment installed:

80 gas ranges
4 gas waffle irons
10 wood and coal ranges
73 gas hot plates
6 gas ovens
21 steam tables
16 electric waffle irons
3 electric griddles
10 electric bake ovens
9 electric toasters
2 electric ranges

This survey disclosed a great deal of interest among the 102 consumers in securing further information on electric cooking and the committee feels that a similar canvass in other cities of this section will show similar results and indicate the great possibilities of load development.

Load Characteristics

Commercial cooking devices have a high demand for original heating but the demand tapers off as the device becomes fully preheated. While no data are available on diversity, we believe that this will be high due to the great variation in the application made of this form of cooking, and the diversity will tend to increase as greater saturation is obtained.

Present Development

With few exceptions, the field is hardly touched and, therefore, present development or saturation is very low. The equipment as offered for sale at the present time is of such variety that almost every cooking operation can be taken care of with an electrical device.

Typical Experiences of Central Station

The Northwestern Electric Company during approximately nine months of more or less special effort upon bake oven load, was successful in placing ten electric ovens, totaling 530 kw. installed capacity and producing an estimated annual revenue of $12,000.

The Washington Water Power Company from March 1 to December 1, 1926, sold nine bake ovens ranging in size from 40 to 240 loaf capacity or approximately 300 kw. of installed capacity of commercial cooking equipment which they estimate will produce approximately $9,000 additional revenue per year. About one-hlaf of the above load is represented by the installation of bake ovens and the balance is made up of restaurnat equipment such as waffle bakers, electric griddles, toasters and other miscellaneous applinaces.

The Utah Power & Light Company has for several years been successfully marketing this type of equipment and consider it a very desirable load.

Endorsement of Central Station Executives

Without exception all those central station executives that we have been able to contact with have given their endorsement to commercial cooking load building, and, of course, those who are employing active sales methods to secure this load are the ones most enthusiastic in their endorsement. It is interesting to note that approximately every one hundred dollars of list value of equipment placed on the line means the addition of approximately 3 kw. in connected load.

Advantages to the User

In answering this portion of our report, we have not taken the usual every day sales phrases which are familiar to all of us, and which of course can be used, but in order to justify the following facts that we are constantly using as sales arguments, we have interviewed many restaurant and bakery owners and chefs, and asked them what they thought were the outstanding advantages in using electric cooking and baking equipment.

Bakers called attention to the constant even heat which can be controlled to whatever degree may be needed for the particular operation. The advantage of this control is particularly apparent in the case of an operation in which one temperature is needed in one compartment and a different temperature in another. Further the heat can be applied from top or bottom, and from front or back of the compartment as is desired. The additional fact that an electric oven is a continual baker is a decided advantage. Cleanliness, saving in floor space, labor saving, and uniform quality of bake are some of the other advantages cited by the bakers.

Restaurant chefs cited advantages which may be summarized as follows: Speed of operation of equipment is imperative and the range top and fry griddle have sufficient weight and heat capacity to give service during the busiest hours. Many cooks and hotel chefs have been very much surprised to know that such equipment could be furnished. One chef in referring to this particular point stated that the equipment has plenty of reserve heat and he could not "kill" it no matter how fast the orders came to him. The heat control feature, by which the range top or fry griddle can be regulated to the required heat whenever needed, was a point also made by the chefs.

All short order restaurant men asserted that the modern range, fry griddle and waffle iron have the necessary speed to take care of the rush orders received in this type of restaurant.

Feature Sales Plan

From reports received from central stations in the Northwest, there seems to be some diversity of opinion as to the correct method of developing this type of load. These opinions fall into two general classifications; the one holding that salesmen should be assigned to this work with their entire time available for sales effort; and the other that co-operation should be given the hotel supply jobber and kitchen equipment house in promoting sales. However, the weight of opinion seems to be in favor of active participation by the central station with men assigned especially for the work. Many reports from the central stations voice the opinion that the supply jobber, who has been engaged in the activity for many years, has accomplished little toward building up this class of load, and that if a real job is to be done the central stations will have to do it.

It appears that the employment of specialty salesmen by central stations for developing this class of load is feasible only in cities having a population of 100,000 or more, since it is only in the larger centers that hotels, restaurants, cafes and bakeries are much interested in the more progressive methods of cooking.

The method of compensation of commercial cooking salesmen most generally followed by power companies is a definite monthly salary plus a commission varying from 2 to 5 per cent of the list price of equipment sold.

Practically all of the central stations in this territory are selling this equipment at factory published list price plus freight from the factory to the point of installation.

Those central stations that favor handling sales through co-operation with jobbers believe that these firms, because of their continual contact with the restaurant and hotel chefs and owners of small cafes, have established a relationship that is of material advantage to the central station in the matter of recommendation on electric cooking equipment.

In some instances the central station merely acts as authority on the cost of operation of the equipment and permits the sale to be made through the hotel supply jobber.

Those central stations who favor aggressively promoting this equipment purchase it from the hotel supply jobber at central station prices and resell to the consumer at list plus freight, thus acting in the capacity of a jobber and for this receive the margin between their cost and the resale price for this effort. It should be borne in mind that liberal terms of payment must be extended, as the average installation often is in excess of two or three thousand dollars and the customer usually is not in a position to pay cash for equipment costing this amount. The central station is in a position to extend payments over a longer period of time than is the case, of course, with the supply jobber unless the supply jobber can turn the paper over to some financing company.

Those central stations employing specialty men to sell commercial cooking equipment should adopt the system of submitting detailed proposals covering the cost of operation, advantages of electric cooking equipment and cost of the equipment itself. A sample of such a proposal is attached to this report. This form of proposal, we believe, should be submitted to every prospect, as the prospective customer will, undoubtedly, be impressed with the businesslike recommendation contained in the proposal; and it is also well to remember that a similar proposal is usually used by the hotel supply jobber.

Construction and Durability

It appears that the equipment now being offered by most of the manufacturers is of such construction that it will give very good and lasting service. We believe that central stations should follow the policy of selling the products of manufacturers that have demonstrated through a period of years that their equipment will give continuous service with a minimum of attention. Representative installations have been in successful operation in this territory for as long as 12 years. Many pieces of equipment in these installations should be replaced by more modern design and higher efficiency devices, but the fact that they continue to operate satisfactorily makes it difficult to sell the customer new and heavier equipment.

Recently one of the largest corporations in America, in purchasing some heavy duty cooking equipment for a cafeteria in its local plant, after thorough investigation was willing to figure a ten year life on this equipment, thereby bringing down very materially the item of depreciation necessary to be written off each year. It was on this basis that the purchaser felt justified in paying almost twice as much for the electric equipment as would have been necessary for any other combustion fuel fired equipment, since it is an established fact that solid fuel fired equipment, as well as gas fired equipment, requires replacement in about five years.

Data on Application Cost and Savings

We believe that the application cost is fully covered in information given in the appended sample proposal.

Elimination of culls, less spoilage because of the baker's ability to have just the desired heat, saving in shrinkage of baked goods and the fact that baked goods will retain their freshness for a longer period were some of the assertions by bakers.

Chefs interviewed claim that there is a saving due to less shrinkage of roast meats and a greater saving of labor due to the fact that fuel storage is not needed. Also less spoilage of food, ease and convenience of control, and simplicity of providing ventilation were other important points considered by the restaurant men in showing a saving in operating cost.

Necessity for Careful Estimations of Current Consumption, First Cost of Equipment and Wiring Costs

We believe that it goes wtihout saying that care should be exercised in furnishing proposals to customers covering current consumptions, cost of equipment, wiring, etc., because conditions of operation and classes of users will vary greatly and will require special attention in each case. Also, the variation in the nature of buildings in which the equipment may be installed would make the cost of wiring different in almost every installation. Everyone realizes how difficult it is to raise a quotation after it has once been made. The customer appreciates knowing the approximate cost before placing his order and would be very much disappointed if an error had been made in estimating the cost of operation lower than it proved to be after the installation was made.

Rates

A promotion of commercial cooking must take into consideration the cost of operation against other forms of fuel and this calls for the application of a rate that makes allowance for the particular type of load.

We find in some sections that central stations are applying their power rate, rating the appliance at one-half of the rated capacity established by the manufacturer. Following are some of the rates offered by different central stations in the Northwest:

The Seattle rate is based upon the Wright demand, 4c per kw-hr. for first 100 hours use of kw. demand, 1c per kw-hr. for the excess used; 25 per cent discount for offpeak of over 21 hp. installed capacity. Offpeak is applicable except betwen the hours of 4:30 p. m. and 9:30 p. m.

Spokane, operating under the Wright demand rate, has the following schedule:

Three cents per kw-hr. for first 50 kw-hr. per kva. demand, 1½c per kw-hr. for next 100 hours use of kva. demand, 1c per kw-hr. for excess.

Boise applies the modified Hopkins demand rate, $2.00 per kw. connected, which includes 50 kw-hr., 2c per kw-hr. for the excess.

Butte applies a block meter rate; 3c per kw-hr. for the first 200 kw-hr., 2c per kw-hr. the next 3,800 kw-hr., 1½c per kw-hr. for the excess.

Portland, Oregon, applies a combined Wright demand and block meter rate covering the first 100 hours' use of demand.

9 kw-hr. @ 8c
70 kw-hr. @ 7c
100 kw-hr. @ 6c
720 kw-hr. @ 5c
1100 kw-hr. @ 4c
Excess @ 3c per kw-hr.

Secondary step:

600 kw-hr. @ 3c
1000 kw-hr. @ 2c
2000 kw-hr. @ 1½c
Excess @ 1c per kw-hr.

Heating appliances are taken at 0.2 demand.

Load Factor

Investigation has disclosed that the load factor of commercial cooking varies from 20 to as high as 50 per cent, the average probably being about 33⅓ per cent.

SAMPLE SALES PROPOSAL
REPORT ON PROPOSED ELECTRIC COOKING EQUIPMENT

for

PUSS'N BOOTS CONFECTIONERY COMPANY

Seattle, Washington
for the

PUGET SOUND POWER & LIGHT COMPANY
July 27, 1926

Note: This estimate is a conscientious effort of the Sales Department to show the meaning and application of rate schedules as filed with the Washington Department of Public Works and is not to be construed as a bid or proposal for furnishing of service; the furnishing of service is to be in accordance with rates filed.

Advantages of Electric Cooking Equipment

1. Saving in fuel cost.
2. Saving in materials, roasted or baked.
3. Cooler in kitchen.
4. Cleaner kitchen.
5. Saving of floor space.
6. Lessening danger of fire or explosion.
7. Lower depreciation of appliances and utensils.
8. Ease and convenience of control.
9. Uniformity of fuel.
10. Uniformity and better quality of food prepared.
11. Less employee turnover.
12. Most modern of kitchen equipment.

Details of Present Equipment and Suggested Replacements

Location	Present Equipment	Electrical
Kitchen	9-ft. Coal Range	2 4-ft. Electric Ranges No. 432R111
Kitchen	1 Gas Boiler	1 Electric Broiler 32 in. wide, 20 in. deep Broiling surface 72 2-lb. Steaks per hour.
Kitchen		1 436 G 13 Griddle.
Kitchen	1-2 Sec. Electric Waffle Iron	No change
Kitchen	Coffee Urn Heaters	No change
Kitchen	Steam Tables	No change
Kitchen	Egg Boilers	No change

Analysis of Estimated Current Cost for Operating New Equipment

Total kw. connected, of new equipment	60 kw.
Average rate per kw-hr. for new equipment	$0.01
Estimated number of kw-hr. required for new equipment (based on an average of 1,500 meals per day) 400 watt-hr. x 45,000	18,000 kw-hr.
Estimated cost of current per month, $0.01 x 18,000 kw-hr.	$180.00

Catalog's numbers and prices of equipment f.o.b. Puss'n Boots Confectionery Company kitchen, connected to wiring furnished by Puss'n Boots Confectionery Company for that purpose.

2 No. 432-R-111 Edison Hotel Ranges	$1,351.60
2 No. R-1P-170 Edison Range Backshelves	76.80
1 No. 431-B-6 Edison Horizontal Broiler	455.60
1 No. 436-G-12 Edison Heavy Service Griddle	177.70
Total	$2,061.70

Explanation of Advantages of Electric Cooking

1. **Fuel now used**
   Gas for Broiler and Coffee Urns ..... Undetermined
   About 4 tons of Coal at $13.50 per ton ..... $ 54.00
   Estimated cost of electricity 180.00
   Saving per month ..... Undetermined
2. **Savings in Materials Roasted or Baked**
   Meats roasted electrically shrink from 5 to 10 per cent less than other fuels used. (This figure obtained from tests made by Cleveland Hotel, Cleveland, Ohio, and Edgewater Beach Hotel, Chicago, Ill.)
3. **Cooler Kitchens**
   Heavy duty electric range ovens are much better insulated than those built into other ranges.
   Less cooking-top surface is required; not necessary to have all of top heated when all of surface is not needed.
4. **Cleaner Kitchen**
   Total absence of smoke or gas fumes.
5. **Saving of Floor space**
   Electric ranges usually require only 70 to 90 per cent of the cooking surface necessary with other fuels. This is due to the fact that the electric range top can be kept at a uniform temperature, while the other types of ranges are apt to have "hotspots" on the top.
6. **Lessening Danger of Fire or Explosion**
   No flame or gases.
7. **Lower Depreciation of Appliances and Utensils**
   Due to absence of chemical action or combustion.
8. **Ease and Convenience of Control**
   Only a turn of a switch is necessary to obtain the desired heat on surface.
9. **Uniformity of Fuel**
   Voltage practically constant.
10. **Uniformity and Better Quality of Food Prepared**
    With electric range it is possible always to duplicate cooking results.
11. **Less Employee Turnover**
    This statement has been proven in hundreds of installations throughout the country. In this city we refer you to:
    Kimball and Harrison, Chamber of Commerce Bldg., Seattle.
    Swedish Hospital, Seattle.
    Sorrento Hotel, Seattle.
    Mrs. Davidson's Lunch, Seattle.
    Englewood Golf Club, Seattle, and others.
12. **Most Modern Kitchen Equipment**
    This electrical equipment has passed the experimental stage. It is taking its place in the hotel and restaurant the same as the domestic electric range in the home.
    It will pay for itself in saving over other methods of cooking many times in years to come. Service required for this type of equipment has been negligible and carries a one-year manufacturer's guarantee.

Competitive Power*

The subject of competitive power is, indeed, a broad one covering, as it does, all forms of power which might in any way be used in competition with what is commonly spoken of as central station service, or electric energy furnished by a public utility company.

Scope of Discussion

Fundamentally, at least, from a utility man's viewpoint there are but two sources of power, i.e., heat and water power. Basically, the latter would fall under the former for the elevation of water and its consequent tendency to seek a common level is but a manifestation of the action of the sun's rays.

Here in the Northwest some communities, factories and plants are so situated that they are able to utilize water power either to operate their equipment through direct drive or to generate electric power in competition with the utility serving that particular territory, but the many factors entering into the developing of hydroelectric energy are so varied and differ so greatly wtih each such installation that it is out of the question to apply any fixed set of rules in an endeavor to determine costs. This being true, and since a discussion of this source of competition would be so wide in its various ramifications as to confine the discussion in a paper of this length to generalities only, it is felt that nothing of value to the association could be brought out in such discussion. We will, therefore, not attempt to treat of this phase of the subject at this time, but will confine our efforts to the other source mentioned.

Steam Competition

Derivation of power directly from heat, as we all know, is accomplished either through the medium of steam or the internal combustion engine. Great strides have been made in recent years in both of these methods of converting heat into motive power. The turbine has practically superseded the reciprocating engine, while the advent of the automobile has rapidly brought the internal combustion engine to its present high state of perfection.

While a large proportion of applied power formerly operated by steam has been changed over to electric drive, still there are certain classes of industries, such as large lumber or saw mills, and plants requir-

* **B. P. Bailey,** Pacific Power & Light Company, chairman. **Puget Sound Power & Light Company:** R. U. Muffley. **Pacific Power & Light Company:** W. H. McMurray. **The Washington Water Power Company:** E. E. Scofield.

ing large amounts of process steam, in which it has been diffcult for central stations to quote a rate which will compete with power of their own production. Numerous lumber mills have been influenced to change over to central station power through the simple expedient of helping them to dispose of the refuse from their saws and planers which otherwise would become a liability on their hands if not burned under their own boilers.

In some of the Middle West and Eastern manufacturing districts the improvement and advancement made in the use of high pressure, high temperature steam has brought the bleeder type turbine into more or less prominence where a large amount of low pressure steam is required for process work. This has resulted in a rather serious form of power competition. Here, again, it is quite apparent that conditions in different localities and different industries vary, and it is up to the industrial engineer of the utility to analyze each case carefully and to let his recommendations be influenced by the facts as found rather than to make a sale that will react to the detriment of his company.

Internal Combustion Engine Competition

Turning now to the internal combustion engine, it is needless to repeat that what we know as the gasoline engine has during the past few years reached a high state of perfection. This is true, at least, when we compare the present gas engine with that of a decade or two ago. It has its place not only in the operation of automotive equipment but also for various other types of portable apparatus in which the use of electric energy would, due to the cost of delivery and short periods of operation, be uneconomical to use. However, for stationary uses with any kind of a load factor within a central station's field of operation, the gas engine should not offer seroius competition because of the cost of its fuel if for no other reason.

Take, however, the same piece of apparatus and redesign it for use with the heavier fuel oils and you have the Diesel engine with its lower fuel costs and consequently a more difficult problem with which to deal. Unlike water power, the Diesel engine is a form of power that is not dependent upon location, nor yet like steam power just mentioned is it peculiarly adapted and confined to certain manufacturing processes; it can be used almost anywhere. Its initial costs as well as its fuel operating costs, vary only as to its transportation costs from the factory and its distance from the various oil centers or markets of the country.

Diesel Efficiency High

While the Diesel is equal, if not superior, to any other form of prime mover in thermal efficiency, its actual commercial efficiency under certain low load conditions, may be even less than that of a simple slide valve engine. It is obvious that inasmuch as the Diesel plant investment is high, with consequent high interest and other fixed charges, if it is operated at low load factors with these same charges prorated over a small power output, the total cost per hp-hr. is apt to be excessive. Therefore, it is quite apparent that it is not the panacea or cure-all for low load factor power costs that the over-zealous salesman is prone to lead the prospective customer to believe.

Nevertheless there is no gainsaying the fact that the Diesel engine is one of the most efficient means of converting heat energy into power that has yet been devised, and during the last few years it has become an important factor in power production, both in marine and stationary work.

Diesel Engine Development

According to Lacey H. Morrison, in his book entitled "Diesel Engines," the total output by American manufacturers of equipment of this kind from the date of its first introduction into this country up until the close of 1922 amounted to 500,000 hp. Since that date numerous additional manufacturers have entered the field until at the present time practically all of the concerns that previously built reciprocating engines, air compressors, and similar equipment, are now putting out one or more types of Diesels, with the result that now it is estimated by the manufacturers themselves that there are approximately 3,000,000 hp. of oil engines in sttaionary plant service.

The oil engine in principal is different from the well known gas engine only in the manner of fuel injection and ignition. Considerable effort has been put forth during the past year or more to adapt engines of this design to automobile use, and it is well within the realm of probabilities that we may before many months see autos so equipped on the market. The earlier, and most of the present larger models, employ the four stroke cycle, but the present tendency is toward the two cycle principal, especially in the smaller units.

As we now measure time, especially in the light of present day achievement, the oil engine is comparatively old, the first oil engine employing the Diesel principle having been built in this country in 1898. As yet very little, if any, progress has been made in fuel economy of the Diesel but on the other hand much has been done to improve it in a mechanical way which is reflected by lower maintenance and operating costs, largely because of the fact that it can now be operated and serviced by less experienced and consequently cheaper labor. Again looking at the present day Diesel from the standpoint of gain in thermal efficiency we find that very little headway has been made in its ability to handle the lighter loads except at a material loss in fuel economy.

Fuel Economy a Factor in Diesel Competition

We have before us the fuel consumption curve of a 100-hp. Diesel engine put out by one of the leading manufacturers and note that while it shows a consumption of about 0.44 of a pound of fuel per hp-hr. at full load it swings up to 0.48 at half load and 0.70 at 20 per cent load. Similar data of another manufacturer shows 0.46 of a pound of oil per hp-hr. at full load, 0.48 at three-quarter load, and 0.55 at half load. That this characteristic is recognized by the builders is evidenced by the bulletin of another manufacturer in which, in recommending the equipment for a small 300-kw. plant it was suggested that three engines of approximately 125 hp. each be installed rather than one single unit in order that these might be cut in or out as the load varied, thereby operating each unit at approximately full load in order to take advantage of the lower fuel consumption.

We are laying particular stress on this point as we consider it of considerable importance when working up comparative cost data for competitive purposes, since we have observed that the average oil engine salesman not only does not mention it but is inclined to base his costs on full load efficiency regardless of what the customer's true load cycle may be. Again it is well worth noting that there is very little difference in the fuel economy in the various makes of oil engines on the market. In verification of this is a statement by Morrison as follows:

"Purchasers should not be too much impressed with the astonishing claims made by some particular manufacturer. Under ordinary circumstances the fuel consumption of all Diesels, regardless of the size, will not vary over 5 to 7½ per cent. It is possible under special shop conditions to obtain a record impossible in ordinary operation in the field."

Anyone who has had occasion to use fuel oil is aware of the fact that while the price fluctuates more or less, similar to that of any other commodity, yet the general trend during the past few years has been upward. This has been due not only to the increasing demand on oil for marine and other uses, but to the fact that the oil companies have been constantly perfecting their cracking processes whereby more and more gasoline is extracted from the crude, with the result that the specific gravity of fuel oils has been gradually lowering. This will mean soon either paying a higher price for Diesel oil now rated at 24 plus Baume, or the addition of expensive centrifuging equipment to clear the heavier oil of solids, and a more frequent overhauling of the engine for the removal of carbon. We were recently informed by a representative of one of the large oil companies that even now, for the reasons just mentioned, his company did not favor entering into a contract for the delivery of 24 plus oil. He further states that his concern has recently completed the installation of six large stills for the extraction of gasoline from Diesel oil.

All Costs Should Be Considered

In meeting the competition of the Diesel on a purely cost basis the average central station has little to fear if all costs entering into the operation are considered on a fair and unprejudiced basis. The prospective customer should not be allowed to believe that his only engine operating expense is his fuel cost, for not only is there the additional expense of lubricating oil, cooling water, maintenance, and in many cases additional labor, but as sure as the proverbial death and taxes there must be considered the so-called fixed charges on the investment made up of interest, insurance, depreciation and taxes. This investment in the case of the Diesel equipment is so much greater, and the useful life of the equipment is so much shorter, that the fixed charges item shows up to considerable advantage in favor of electric equipment.

Moreover, the oil engine, horsepower for horsepower, is a great deal larger than the electric motor and with its auxiliaries requires considerably more floor space. Thus in many cases, and particularly so is this true in the new plants, the additional building or housing expense with its attendant fixed charges should be taken into account. The additional item of oil storage likewise should not be overlooked. Not only should the initial cost of the containers or tanks and their installation be considered, but also in plants where it is necessary to store sufficient fuel to last several months in order to insure continuity of supply, the carrying charges on such storage equipment most certainly should be considered a legitimate charge against operating costs, since it is an item of expense that would not be incurred were central station electric power used.

Unethical Diesel Advertising

During the past few years the manufacturers of oil engines have been carrying on extensive advertising campaigns in various trade and technical magazines, which in itself is commendable. But much of the reading matter thus presented is not commendable, being on the other hand a sorry distortion of the truth which is not only misleading but in many cases embodies rank propaganda adverse to the electrical industry. This practice, to say the least, is unethical and unsportsmanlike, and manifests a condition that this association and its affiliated divisions should take immediate action to correct. The competitive power committee considers this of the utmost importance, for the electrical industry generally has in former years been too backward in its endeavors to refute the unfavorable publicity that has been broadcast through the press and otherwise, with the result that public good will has been broken down and irreparable damage done.

As an example of this kind of advertising, there recently appeared in one of our leading technical magazines an advertisement by one of our foremost Diesel manufacturers in which the following statement was made:

"As compared with steam or purchased electricity —Diesel will unquestionably cut power costs 15 to 85 per cent."

This is indeed a broad statement, and, reminiscent of the intoxicated man who offered to whip anybody in the state, certainly takes in a lot of territory.

Another manufacturer, in a bulletin describing his product, states that the important advantage of a Diesel is that the savings compared with the cost of steam or purchased power will soon pay for the installaiton, after which this surplus or added profit will be available for increased dividends. Surely the electrical industry of the country, which itself is one of the largest users of heavy oil engines, should be in a position to ask the manufacturers of such equipment to adhere a little closer to facts and specifically to name any isolated cases which might have given an iota of truth to their statements, rather than to apply those statements to the power field generally.

We hold no brief against the oil engine for it certainly has a place in the power field of the country, but we do take exception to some of the methods employed in trying to market it. To quote from the report of the meeting of the National Competitive Power Committee held in Chicago last November:

"The oil engine is performing a wonderful task in marine work. Oil engines have a distinct field in isolated mines or places away from existing power lines. They are also used to advantage by central stations where the expense of running transmission lines is prohibitive, but in places where the central stations are able to serve their customers it is apparent that the central station service is better in nearly every condition for the customers."

Recommendations

It is the opinion of our national committee that plenty of authentic data is now available on the cost of producing power by Diesel engines. H. C. Thuerk of the Erie Lighting Company, Erie, Pa., has prepared a very able paper on the operation of Diesel engines. This paper makes a study of numerous plants operating over a period of years, and will soon be published and ready for distribution by the national headquarters. Every commercial department should have a copy of this report as it brings out some very interesting information relative to actual operating conditions.

Every power salesman and engineer should have and read the book on "Diesel Engines" by Morrison, published by the McGraw-Hill Company.

In order to get all sides of the story it is the recommendation of this committee that all member companies should subscribe to Oil Engine Power, a magazine published in New York and devoted solely to the Diesel engine and its uses. Bulletins descriptive of their particular equipment as put out by the oil engine manufacturers will be found to be a valuable asset to a commercial department's files.

Eternal Vigilance Necessary

In conclusion it is the opinion of this committee, as has already been expressed by the national committee, that the most important factors in combating power competition are eternal vigilance on the part of the power salesman in keeping in contact with his customers, both present and prospective, so that he will know in plenty of time of a competitive situation. The power salesman should have a thorough knowledge of the operating characteristics of other forms of power, as well as costs, both installation and operating; knowledge of the customers' conditions so that intelligent comparisons of costs may be made; and finally, full knowledge of the operating conditions of his own company so that he may have the proper rate structures to meet competition of this sort.

Industrial Heating*

Various districts represented in this committee report a diversified line of activity so that there are many distinct angles of this work that must be reported upon without going too much into detail.

In the cities, most of the activity is centered upon electric bake ovens installed in bakeries, restaurants and hotels, heavy duty restaurant equipment, heat treating ovens, core baking ovens, electric arc welders, and electric steam boilers, so we can see there are still many applications of electric heat that either are overlooked or are sold with limited success.

Possibilities Listed

Industries of the Pacific Northwest are such that they can all be developed into heavy users of electric heat in many ways, and it is part of our program to campaign in this activity. Listed below are some of the ways in which electric heat may be applied to these industries, and it is in this field that we are to concentrate our efforts.

* **R. W. Clark,** Puget Sound Power & Light Company, chairman. **Grays Harbor Railway & Light Company:** H. G. Kelsey. **Idaho Power Company:** J. B. McLain. **Northwestern Electric Company:** R. W. Faville. **Mountain States Power Company:** Glenn L. Jackson. **Pacific Power & Light Company:** H. E. Baker. **Portland Electric Power Company:** J. D. Scott. **Utah Power & Light Company:** Glen B. Walker. **The Washington Water Power Company:** E. E. Scofield.

Furniture Manufacturing—Glue pots, wax melters and small furnaces for tempering machine tools.

Canning Industry—Solder pots, lacquer ovens, possibly for cooking vegetables, fruit, fish, meat and syrups.

Lumber Mills—Heat treating furnaces for machine tools and special dry kilns.

Steel Mills—Electric furnaces.

Foundries—Furnaces for melting brass, aluminum, copper, steel casting electric furnaces, annealing furnaces, core baking ovens, etc.

Newspapers—Stereotype pots, heat for matt drying, molting pots for type setting machines.

Lithograph and Printing Plants—Stereotype pots and heat for matt drying.

Machine Shops—Furnaces for heat treating, babbitt pots, arc-welders, rivet heaters.

Automobile Factories and Repair Shops—Lacquer ovens, enamel ovens, heat treating furnaces, core baking ovens, annealing ovens, spot welders, arc welders, rivet heaters.

Sheet Metal Works—Arc welders, spot welders, rivet heaters, solder pots.

Railroads—Rivet heaters, arc welders, spot welders, heat treating furnaces, various kinds of ovens, steel casting electric furnaces.

Boiler Works—Arc welders, rivet heaters, spot welders.

Car Shops—Heat treating furnaces, welders, rivet heaters, core baking ovens, steel casting electric furnaces.

Shipyards—Solder pots, welders, rivet heaters, furnaces, various kinds of ovens.

Electric Repair Shops—Ovens for baking windings, welders, heat treating furnaces.

Body and Fender Works—Enameling ovens, rivet heaters, welders.

Gear Works—Electric steel casting furnaces, heat treating furnaces, case hardening.

Garages—Rivet heaters and welders, vulcanizers.

Brush Factories—Ovens, glue pots, vulcanizers.

Cleaning, Dyeing and Tailoring Establishments—Electric flat-irons, electric steam boilers.

Clay Products—Electrically-heated air dryers for molds.

Cracker Factories—Bake ovens.

Candy Factories—Water heaters, applications of heat to boiling pots, steam tables, chocolate dipping, etc.

Wholesale Groceries—Water heaters, applications to mixing vats, coffee and peanut roasting ovens.

Packing Plants—Water heaters, dipping vats, egg paraffining machines.

Dairies—Water heaters, egg paraffining machines.

It is evident that we have a vast field open to us for development. In fact, every form of manufacturing has use for electric heat in one way or another, such as crane operators' cabs, small detached quarters, bridge and elevator operator stations.

Specific Applications Discussed

We wish to call attention to a special application recently completed in the Northwest in the bakery field. This is an electric traveling oven which is designed to bake Swedish crisp and hardtack, has a connected load of 300 kw. and is capable of baking 6 charges of 300 hardtacks for each charge, or 1,800 units per hour. Kw-hrs. per pound of dough will be more accurately determined later. Information on this will be available at a future date.

Another interesting application was recently put on the lines in the district, namely, a 90-hp. motor generator set for arc welding. This machine takes care of 6 portable arc-welders for use in a sheet metal shop manufacturing tanks, uptakes, stacks, and metallic roofing. It is found that while there is a connected load of 90 hp. the actual operating load on this machine is only 50 per cent of its rating due to the natural diversity of the six machines with each other, so that the sheet metal manufacturer feels confident he can double the number of portable welders on this machine as planned. This machine operates on 440-volt, 3-phase, 60-cycle current on the motor side and generates 60-120 volts d.c. at the arc. This manufacturer operates one of the largest businesses of this kind on the Pacific Coast and is very enthusiastic over the success of this method of welding both as to operating cost and production. In addition to this advantage he reports a better class of work with much less spoilage of material.

We find that stereotype pots electrically heated are gaining in favor with the newspapers in this section and one recently installed in the Northwest is now in active operation. Reports on this installation show a demand of 15 kw. which is fairly low, but this is due to the fact that this apparatus is especially adapted to this class of work with the temperature thermostatically controlled to maintain a heat of 650 deg. F. It is so arranged that by the use of a Y-delta connected switch, the electric input can be controlled to keep the lead when not in use, at about 450 deg. F. or just above the freezing point of the metal. Radiation losses are kept at a minimum by special insulation. This pot has a daily consumption of about 120 kw-hr.

Electric Heat in Agriculture

Another phase of industrial electric heating that is developing into something really important is the use of electricity in the agricultural districts. The Pacific Northwest is fast becoming the egg and poultry center of the United States, shipping quantities of eggs and poultry to the East, and it is interesting to note what part electric heat is playing in this development. Some of the uses to which electricity for heating can be put in the agricultural section are: incubators, nurseries and brooders for poultry raising, sterilizers for dairy equipment, and heaters for hot beds and nurseries in shrub raising. As an example of what can be worked up in the way of heating load in the poultry business, we quote here what one company has accomplished.

This company has connected to its lines approximately 1,000 incubators of various sizes, but quotes figures on a 15,000-egg incubator to show what can be done. This 15,000-egg machine with a connected load of 1 kw. using an average demand of 0.5 kw. consumes about 25c worth of electricity per day against the price of $1.43 for coal oil, and makes a labor saving of 12 to 16 man-hr. each day. This incubator has a mechanical arrangement for turning the eggs so that the 15,000 eggs can be turned in less than two minutes, whereas the hand method takes six hours per day for this number of eggs. In addition, the electric incubator eliminates another six hours for the trimming, filling and regulating of the coal oil burners of the old style incubators, and, finally, raises the hatching percentage from 40 per cent to 65 or 70 per cent.

The next step in the raising of chicks is in the nursery which has a connected load of from 2 to 3½ kw. and from there the chicks pass through the brooding stage. In connection with the application of heat in brooders, this particular power company found it advisable to have its own engineers design a new type of brooder which is thought to be an ideal brooder. The company's engineers were assisted by the State Agricultural Research Bureau. In the last two years, 300 of these have been placed on the company's lines by two factories manufacturing them, and 300 sets of plans and specifications have been furnished by the power company to farmers who desired to make their own.

Information to Be Spread

The companies represented on this committee report a variety of activities, but the question troubling them seems to be how to get this information to each other. It has been suggested that when any one of the interested companies makes a really worthwhile application of electric heat, it should then and there make up a report on the installation and its operating facts as completely as possible and forward a copy to each of the member companies of this association, each company keeping a loose-leaf binder or some other form of filing system for these reports. Thus, valuable data on installations in our own neighborhood, and likely to fit the peculiar conditions of each individual company, will be readily available, and the hurried preparation of data requested by another company will be made unnecessary. This suggestion will be brought up for consideration at our next committee meeting.

Complete Survey Of the Field Essential

In closing, it would seem that only the surface has been scratched in this field, but a start has been made and all should endeavor to be more active in selling the industrial electric heating idea to consumers. Results many times greater than we have shown this year will be the reward, and in line with this idea a review of the committee's report at the midwinter meeting would be of benefit to all concerned. In this report it was decided to investigate the possibility of the insurance companies lowering rates on industrial plants using electric heat to replace other forms of fuel fired apparatus. We hope to report progress on this later. It was also recommended that the companies make a complete survey of the industrial field with a view to lining up prospects for electric heat. This has been started by

some of the member companies, who also report the assignment of men to follow up the industrial electric heating branch of the power business as was recommended in the midwinter meeting report. We can, therefore, report some progress and will continue to devote our energies to increasing the sales of industrial electric heat to the greatest extent possible under the circumstances.

Merchandising*

At the present time there are special committees organized in the association for the purpose of considering all matters in connection with certain major appliances, such as the electric ranges, water heaters, refrigerators and heavy duty appliances. Naturally these committees consider all problems in connection with such major devices so that the merchandising committee, under the present setup, must confine its report to smaller appliances and some subjects in connection with merchandising in general. We would suggest that in the appointment of future committees, consideration be given to the advisability either of consolidating some of the above mentioned committees, so far as the merchandising aspects are concerned, or more clearly defining the scope of each committee's work.

The merchandising committee in this report is making no specific recommendations regarding the sale of electric ranges, water heating, refrigeration and heavy duty equipment.

Tie-In With National Program

It is the duty of each geographic section to assist as far as possible in the program undertaken by the National Electric Light Association, and one of the activities of the national merchandising committee this year is to encourage all central station companies to tie into the national program of appliance selling. This program specifies that the following appliances should be featured during the months shown:

February	Waffle Irons
March	Toasters
April	Percolators

In addition to the above, further activities for the fall and winter months will be announced at a later date, and it is hoped by this committee that every central station in the Northwest conducting a merchandising department will make an effort to tie into these campaigns, which they can do to their own advantage because of the increased amount of national advertising support by the manufacturers during the periods indicated on the devices featured during that month. At the meeting of the national committee in Chicago in November, 1926, it was reported by manufacturers that a noticeable increase in volume of business was apparent from this national campaign, and this committee urges member companies to plan special activities to harmonize with the national program as outlined above.

Consistent 12-Month Selling vs. Spasmodic Campaigns

It is not the purpose of this committee to set up any definite guide for conducting merchandising departments. We feel, however, that serious consideration should be given merchandising on an annual basis. There is a marked tendency in central station merchandising at the present time to conduct special campaigns during a particular period of the year, and then give no further attention to that device during the balance of the year. In many cases this has proved a boomerang, with the result that while the campaign itself was successful, yet the volume of business on the particular device for the twelve-months period was no greater than normal, and in many instances considerably below what might have been secured by consistent twelve months activity on such device. Central station merchandising executives should give serious attention to this matter and endeavor to work out a program which will result in the greatest volume of business on an annual basis for each of the appliances sold by them.

The impression should not be gathered from the above that this committee does not believe in campaigns. Campaigns are vital to the success of any merchandising program, but the point we wish to make is that one successful campaign will not produce a good year's result any more than one good drive will make a satisfactory golf score. It is year around results that count, and success during a particular short campaign, which in itself may be spectacular, may not yield at the end of the year a satisfactory volume of business on that device. We recommend that earnest study be given this problem with the view of carrying on concurrently some activity on all of the devices for sale to the public.

Use of Employees in Selling

The committee recommends for analysis the practice which has been adopted by a number of member companies and proven highly successful, of using all employees in selling appliances, particularly special items, such as kitchen lighting units, percolators, toasters, and the like. Experience has shown that greater interest is displayed by departmental employees in the merchandising department of the company when a plan is offered that enables them to earn extra compensation for special effort during evenings, and other spare time.

Each company can best determine how this extra compensation should be paid.

A number of the companies reporting pay a regular commission to employees other than those in the sales department for any sales made; also a special commission for prospects turned in. Some companies pay at the end of each year a bonus which is divided among the employees of the districts reaching their quotas of a certain pre-determined volume of merchandising business. A number of companies have also found it desirable to pay office attendants in the smaller offices, where the employment of a regular sales person is not justified, a small commission in addition to their salary on all of the merchandise sold by them. This has a tendency to make the employees more interested in making sales than would be the case if the employees were not paid extra compensation. This last mentioned plan is especially desirable where regular salesmen are not operating in the territory.

The good will engendered by having all employees interested in sales should not be overlooked. When it is found that almost any employee is interested enough to assist customers in any of their relations with the company a good impression is created.

Uniformity of Activity

We suggest for consideration the desirability of companies, having two or more towns reasonably close together geographically, conducting campaigns on the same device simultaneously. This plan presupposes that all of the towns carry in general the same kind of merchandise, which is desirable from a buying standpoint, because such goods can be purchased in quantity. There are a number of advantages in such uniform activity throughout the towns or districts of a company, among which may be enumerated the following:

1. Saving in cost of producing advertising.
2. Opportunity to inject contest spirit.
3. All customers have equal opportunity to buy under campaign terms.
4. Transfer of excess stock from one district to another if necessary.

Convenience Outlets

The sale of electrical devices of all kinds, of course, depends largely upon the customers' facilities for using such devices. For this reason it is desirable to keep before customers at all times the necessity for having convenience outlets. Every opportunity should be taken to remind customers that they should have more convenience outlets installed. Many manu-

* **R. M. Bleak,** Utah Power & Light Company, chairman. **Idaho Power Company:** L. W. Brainerd. **Pacific Power & Light Company:** V. H. Moon. **Puget Sound Power & Light Company:** R. W. Clark. **The Washington Water Power Company:** R. B. McElroy.

facturers will assist in this respect by placing a tag on each appliance manufactured by them calling attention to the desirability of convenience outlets in the home. This should be supplemented by newspaper advertising and frequent store displays.

Some companies have found it very desirable to increase the number of convenience outlets by offering them as premiums in connection with the sale of larger electrical devices, such as floor lamps, washing machines and vacuum cleaners. We suggest that where opportunity affords this plan be given consideration.

Christmas Lighting Activity

The idea of using colored lighting by residence customers during the holiday season is growing rapidly throughout the country. In some sections prizes have been awarded through electrical leagues for the best decorated homes during the holiday season. We suggest the desirability of interesting city officials, civic clubs and newspapers in a plan of this kind, looking toward a general decoration of cities and towns during the holiday season. One very effective idea, which has been accepted readily by customers, has been the purchase of a simple two-way plug for display on front porches, using a 25-watt green and a 25-watt red lamp. This is, of course, the simplest kind of decoration, but with a little encouragement on the part of central station commercial departments, coupled with the interest that can be aroused in civic authorities, a more widespread use of light in holiday decoration can be brought about in any town, and it will be found that the Christmas spirit is just a little keener as a result of such decoration than it would be otherwise. In some cities in the Northwest division thousands of homes now decorate with light during the holiday season, and the idea is spreading rapidly.

Co-operate With Women's Clubs

Probably one of the most effective channels through which we can carry the message of electrification and the use of appliances to the home is through the women's clubs. Many ways of enlisting the support of club women will occur and we want again to remind each company of the desirability of having their support.

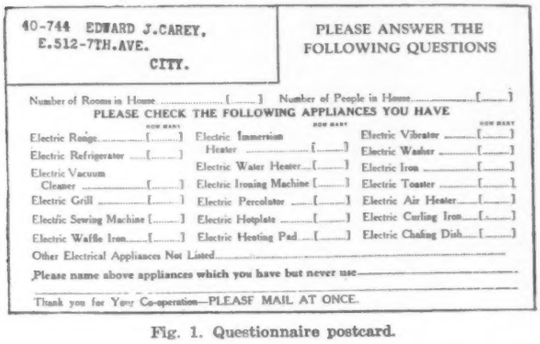
Appliances as Load Builders—Spokane Survey

Few attempts have been made to determine the value of appliances as revenue producers, and while any information gathered in one section may reflect a condition which would not apply in another, nevertheless this committee believes any such information to be of value, and so submits herewith data on a survey conducted by The Washington Water Power Company at Spokane.

The purpose of this survey was two-fold: First, to determine the saturation of the various appliances in the city of Spokane; second, to ascertain if the kw-hr. used per month increased in proportion to the number of appliances in the home.

A letter, with a return post card enclosed, such as are here reproduced, was sent to 2,000 residential customers, the recipient being requested to fill in and return the enclosed post card. The mailing list was obtained by taking at random ten names from each of the 200 meter routes, so that a complete cross-section of the community was obtained. A compilation of the information received probably revealed a close approximation of the appliance saturation percentage in Spokane. The results cannot be considered absolutely exact for the reason that people with many appliances might have been more willing to reply than those with few or no appliances. However, the results probably reflect a more accurate estimate than could be made without data.

Tables 1 and 2 show the results of this survey in detail.



40-744 EDWARD J.CAREY,
E.512-7TH.AVE.
CITY.

PLEASE ANSWER THE FOLLOWING QUESTIONS

Number of Rooms in House ..... [.....] Number of People in House ..... [.....]

PLEASE CHECK THE FOLLOWING APPLIANCES YOU HAVE

	NOW HAVE		NOW HAVE		NOW HAVE
Electric Range	[.....]	Electric Immersion Heater	[.....]	Electric Vibrator	[.....]
Electric Refrigerator	[.....]			Electric Washer	[.....]
Electric Vacuum Cleaner	[.....]	Electric Water Heater	[.....]	Electric Iron	[.....]
Electric Grill	[.....]	Electric Ironing Machine	[.....]	Electric Toaster	[.....]
Electric Sewing Machine	[.....]	Electric Percolator	[.....]	Electric Air Heater	[.....]
Electric Waffle Iron	[.....]	Electric Hotplate	[.....]	Electric Curling Iron	[.....]
		Electric Heating Pad	[.....]	Electric Chafing Dish	[.....]

Other Electrical Appliances Not Listed .....

Please name above appliances which you have but never use .....

Thank you for Your Co-operation—PLEASE MAIL AT ONCE.

Fig. 1. Questionnaire postcard.

TABLE I—Results of survey.

Post Cards mailed out 2,000
Post Cards mailed in 702
Post Cards used in survey 669

Appliance	Number	Per Cent Saturation	Appliances Never Used	Appliances Seldom Used	Appliances Out of Repair
1. Electric Iron	690	103 1/7	0	0	0
2. Electric Vacuum Cleaner	434	63 1/3	0	0	0
3. Electric Curling Iron	425	63 1/2	13	0	1
4. Electric Toaster	326	48 8/11	10	4	1
5. Electric Washer	302	45 1/7	2	0	0
6. Electric Percolator	245	36 2/3	7	1	0
7. Electric Waffle Iron	226	33 5/6	2	3	0
8. Electric Range	205	30 2/3	1	0	0
9. Electric Air Heater	203	30 1/3	10	3	0
10. Electric Water Heater	187	27 8/9	0	0	0
11. Electric Hotplate	148	22 1/8	15	0	0
12. Electric Sewing Machine	133	19 5/6	4	0	0
13. Electric Grill	130	19 1/3	8	0	0
14. Electric Heating Pad	101	15 1/11	5	2	0
15. Miscellaneous	70	10 1/2	3	0	0
16. Electric Vibrator	61	9 1/9	9	1	1
17. Electric Refrigerator	28	4 1/5	0	0	0
18. Electric Chafing Dish	27	4	5	0	0
19. Electric Immersion Heater	23	3 1/3	0	0	0
20. Electric Ironing Machine	21	3 1/7	0	0	0
Totals	3,985		104	14	3

Average appliances per customer ..... 5.95+ each
Average appliances never used 2 3/5%
Average appliances seldom used 3/10%

These data are submitted by the committee as general information without drawing any conclusions. It is apparent, however, that the customer that has several appliances not only uses more current as a result of the number of appliances, but uses each device more generally than the customer that has but one or two.

TABLE II—Summary, ranges and water heaters not included.

No. of Customers Considered	No. of Appliances Used	Annual Kw-hr.
Case 1—10	0	192
Case 2—35	1	252
Case 3—49	2	276
Case 4—78	3	336
Case 5—72	4	348
Case 6—66	5	372
Case 7—54	6	552
Case 8—51	7	516
Case 9—28	8	552
Case 10—13	9	828

General

Conditions vary in different companies, but fundamentally our problems are very much the same. This committee hopes that the few suggestions outlined above will be of some assistance to member companies in building a well balanced merchandising department, keeping in mind at all times that this department not only is the neck of the bottle through which the central station revenue must come, but also that a well organized, courteous personnel in the merchandising department is one of hte greatest factors in good will building that the central station has at its command.

Customer Relations*

The function of the customer relations committee of the Commercial Section is to formulate efficient methods of conducting relations with customers.

A study of these methods by this committee has led into practically every department of electric utility operation, so that a full report on this subject would cover a study of subjects also being made by committees in the Accounting and Public Relations Sections of this association.

The national customer relations committee has set up the following subjects to be studied:

A. Application routine	E. Complaints
B. Forms in use	F. Meter reading
C. Order routine	G. Collections
D. Inquiries	H. Credits.

It will be seen that departmental jurisdiction over the above subjects varies by individual company organization, and for this reason the committee decided that its best work could be done by gathering information on customer relations practices in this Northwest division on the above subjects and submitting this information to the national committee which publishes the monthly "Service Suggestions" in bulletin form for distribution to all member companies.

Other geographic committees are doing likewise with the result that all member companies are receiving information on the best customer relations practices throughout the country.

These service suggestions may be referred to the proper jurisdiction in each company for application, whether it be commercial, accounting or public relations, thus giving effective distribution to information on the latest good practices in customer relations.

That these service suggestions might be more widely distributed, it has been arranged to print them in the N.E.L.A. Bulletin, and in addition distribute reprints for bulletin board use.

The following service suggestions have been or will be issued this association year:

July-Aug., 1926—"Promoting Customer Relations"—preliminary statement Part 1. A reprint of 1924-1925 report of Customer Relations Bureau, Pacific Coast Electrical Association.

Sept.-Oct., 1926—Continued from above. Part 2. "A few instructions to guide employees in their daily relations with the public."

Nov.-Dec., 1926—Trouble call verification.

Jan.-Feb., 1927—Eliminating service delays, the meter reader, collections, credits, deposits, commercial department organization, form letters and handling of adjustments for grounds.

This committee believes that the work of future committees in the assembling of subject matter for service suggestions will be expedited greatly by the reorganization of the Commercial Section now proposed to provide better continuity of program from year to year, and heartily recommends the adoption of the proposal.

* **E. L. Crockatt,** Eastern Oregon Light & Power Company, chairman. **Portland Electric Power Company:** W. W. Sansom. **Puget Sound Power & Light Company:** H. J. Gille.

Domestic Electric Range*

The work of the electric range committee of the Northwest Geographic Division for the year 1926 follows the program of the national range committee. This program provides for the publication and distribution to the electrical industry at large through the geographic divisions of the N.E.L.A. a synopsis of the methods employed and results accomplished by the several outstanding range sales plans carried on by utility comapnies and other electric distributors throughout the country.

As a further part of its work, the national committee has undertaken to make up an index of all the range sales helps and range campaigns that have been published in trade journals, so that from this index anyone may turn to any of the various range campaigns that have been written up or to articles on electric ranges covering phases of the subject in which they might be interested.

This committee felt that by co-operating with the national committee in its program it could best serve those interested in furthering the sale of electric ranges and electric cooking.

Some information already has been forwarded to the national committee dealing with successful range campaigns in our territory, to be edited and distributed to member companies as serial reports. The first serial report of the national committee was published in March of this year as N.E.L.A. Publication No. 256-38 to which the attention of member companies is directed. It is the plan of the national committee to issue other serial reports just as often as material can be gathered dealing with successful range campaigns or any other sales helps which would be of value to the selling of electric cooking.

* **J. F. Orr,** Idaho Power Company, chairman. **Idaho Power Company:** G. H. Davis. **Pacific Power & Light Company:** V. H. Moon. **Puget Sound Power & Light Company:** T. A. Mardon. **Utah Power & Light Company:** W. A. Huckins.

Domestic Electric Refrigeration*

The refrigeration committee, from obsrevations and discussions brought out at the midwinter conference of the Commercial Section of this association and from the results of a questionnaire sent to committee members, reports as follows:

Three Sales Policies

At this stage of development domestic electric refrigeration is purely a sales problem. There are some differences of opinion among sales executives as to how best to promote the sales and the three following methods were discussed: The first method is for central stations themselves actively to sell refrigeration but in close co-operation as to terms, selling plans, etc., with dealers and manufacturers' agents; the second is for central stations to sell machines in active competition with other dealers; and the third, to withdraw from the sale of domestic refrigeration entirely and leave the sales to dealers and manufacturers' agents. The first plan, by which central stations sell in close co-operation with dealers and manufacturers, seems to be the most popular and the one used by nearly all the power companies in the Northwest district. All executives realize the value of the load and are satisfied that its characteristics are such that it will in no way interfere with other loads they have on their system, and therefore are willing to connect up this load without any construction limitations such as were necessary with the electric range and water heater.

Rates

The question of a compensatory rate was discussed at some length in the domestic refrigeration report of 1926, and since it is the consensus of opinion of this committee that the question of rates is the most important one in connection with this desirable load, the following paragraphs from last year's report are quoted:

* **L. A. Lewis,** The Washington Water Power Company, chairman. **Idaho Power Company:** J. F. Orr. **Northwestern Electric Company:** J. C. Plankinton, **Pacific Power & Light Company:** G. C. Sawyer. **Portland Electric Power Company:** A. C. McMicken. **Puget Sound Power & Light Company:** H. J. Gille. **Utah Power & Light Company:** R. M. Bleak.

It is found that a wide disparity of rates exists in connection with home electric refrigeration and that ideas of the rate departments of various central stations are widely at variance as regards proper classification of this type of business. This committee believes that considerable discussion might be engaged in to advantage on this subject particularly during the early stages of development as it is obviously difficult to make any major adjustments after a large amount of this business has been secured.

Some companies feel that refrigeration business should be taken on the regular combination lighting and cooking rates, which means, of course, that all of the refrigeration consumption would be on the low step. These companies feel that the customer develops into a high load factor customer and is entitled to his excess kw. hours at a low rate. Other companies feel that the value of the service rendered by a domestic refrigeration unit is far above this low step rate, and are of the opinion that some method must be devised to bill the customer at a price commensurate with the value of the service, either through additional steps in existing rates for customers using refrigeration, or if necessary, through an additional meter at a special refrigeration rate. These are matters which should receive the early consideration of member companies.

Some companies, in their desire to develop certain classes of load, especially water heating service, have so quoted their rates that the refrigerator load is now served at the low step of the rate which is not compensatory and far below that which the ordinary customer is willing to pay for the service. One of our important companies has recently filed an inducement rate to take care of this condition—a one-metered rate taking into consideration the load that is to be connected and providing for a compensatory rate for the particular class of service rendered. Electric refrigeration has undoubtedly called attention to the need of an inducement rate which will be compensatory for the class of service rendered and still of such a nature that it will be low enough to provide for any additional load that is desirable and available.

Servicing

Maintenance is undoubtedly a decreasing factor and even today is not one to deter central stations from pushing the installation of domestic refrigerators as rapidly as possible. All dealers seem to be charging the customer a part or all of the maintenance cost after the first year's guarantee period with but few unfavorable reactions The question has arisen as to who will be responsible for the maintenance of machines years hence when the revenue will be just as desirable as it is today, but when the dealer either wil lhave been changed, or will have been withdrawn as the manufacturer's representative in the territory as has been the case with other types of apparatus. It seemed to be the unanimous opinion of the central station executives present, that the power companies will have to be prepared to do whatever servicing is necessary regardless of the make of equipment, just as they now are servicing other electrical devices. The opinion of the manufacturers' representatives seems to be that they will always maintain service departments, or that when there are a large enough number of plants in operation, service men will always be available just as is the case with the automobile of today.

There was a tone of disappointment among the central staiton sales executives over the result of the 1926 sales. This was counteracted, however, by the manufacturers who have set a Northwest quota of 12,000 domestic and commercial plants for 1927. There seems to be no conflict between the icemen and the power companies as was apparent a few years ago. In many of our cities the ice delivery companies are now becoming agents for electric domestic refrigerators.

Home and Industrial Lighting*

The lighting committee, believing that more fundamental and academic knowledge of the factors governing good lighting practice should be had by men in all branches of the industry recommending, selling or installing wiring and lighting equipment, decided to confine its activities to organizing and conducting "lighting schools" for representatives of electrical contractors, fixture dealers, electrical supply jobbers and electric service companies, in the belief that such schools would result in improving the standard of lighting in the homes, offices, stores and factories of our customers.

Organization of Lighting Schools and Attendance

Early in September the Pacific Coast Division of the National Lamp Works offered to provide its lighting expert, Clark Baker, of Oakland, Calif., without expense to the association, to conduct such schools as the committee might organize. In October the lighting committee was organized with representatives of electric service companies, lamp manufacturers, glassware manufacturers, reflector manufacturers and supply jobbers, either serving on the committee or assisting it.

Three schools were organized and conducted, one in Portland the week of Feb. 14, 1927, one in Seattle the week of Feb. 21, and one in Spokane the week of Feb. 28. The lighting committee was divided into three committees, each to conduct one school. At Mr. Baker's request, each school was to have been limited to fifty men, ten from electric service companies, fifteen from electric supply jobbers and twenty-five from contractor dealers, so that the classes would not be unwieldy and that real instruction could be given. In spite of the best efforts of the committees to comply, the enrollment in the three schools was 190 men, with others not enrolled looking on.

The attendance at the Portland school was 75, at Seattle 61, and at Spokane 54. Those in attendance were jobber salesmen, fixture men, electrical contractors and their estimators, lamp salesmen, reflector and glassware salesmen, and electric service company men. Of the 190 enrolled in the three lighting schools, 48 represented electric service companies, 41 were representatives of jobbers and manufacturers, and 101 represented contractors and delears. Many of these men traveled considerable distances in order to attend. A registration fee of ten dollars was required of each man enrolling, and this fee was refunded if all classes were attended. The attendance at all three schools was practically one hundred per cent.

Conduct of the Schools

The classes were purely educational and void of all commercialism, all manufacturers and jobbers cooperating to the fullest extent. Five classes were conducted by Mr. Baker in each city, two afternoon classes and three night classes. Mr. Baker used what he termed the N.E.L.A. lighting course "boiled down," because of the limited time. Technicalities were avoided, and the subjects and their application were presented on a simple and practical basis. Demonstrations of all lighting principles taught were made, and text-books were supplied by the committee to all who enrolled. The classes were not for illuminating engineers, but for the men in the industry that daily are planning wiring and lighting installations, wiring homes, stores, offices and factories and installing lighting equipment in them. The course given by Mr. Baker embraced the following:

Terminology (with demonstrations).

Calculations (with demonstrations), for industrial lighting, for store lighting, for show window lighting, for office lighting, for school lighting.

Color lighting (with demonstrations).

Sign lighting.

Street lighting.

Residence lighting.

Sport and special lighting.

Mr. Baker was ably assisted by members of the committee who acted as assistants and assistant instructors.

* **A. C. McMicken,** Portland Electric Power Company, chairman. **Northwestern Electric Company:** Fred Zaugg. **Portland Electric Power Company:** F. H. Murphy. **Puget Sound Power & Light Company:** R. W. Clark. **The Washington Water Power Company:** L. A. Lewis, L. V. Ross.

School Committees.—Portland: Frank Bliss, National Lamp Works; J. L. Casey, Westinghouse Lamp Company; J. Hampton, Edison Lamp Works; A. L. Bergeron, Miller Company. **Seattle:** P. L. Hoadley, I. P. Frink Company; E. A. Irons, Westinghouse Lamp Company; T. W. Carlson, Benjamin Electric Manufacturing Company; Walter Potter, National Lamp Works; Jack Reinke, Edison Lamp Works. **Spokane:** G. J. Hain, Westinghouse Lamp Company; W. R. Clark, Edison Lamp Works.

The committee takes this means of expressing to Mr. Baker its appreciation of the splendid manner in which he handled these schools and conducted the classes. Every moment was both interesting and instructive, and the apparatus with which he made actual demonstrations added considerably to the rapidity with which the instruction could be assimilated, and to the interest. His personality, his knowledge of his work, and his love for it, all contributed toward making these schools the most successful and constructive work accomplished by the lighting committee in recent years. Likewise the committee is grateful to the electrical supply jobbers and lamp and reflector manufacturers' agents for the splendid cooperation they gave, particularly in enrolling students and in assisting in conducting the schools.

Success of the Schools and Recommendations

The large number of letters received from men attending these schools is probably the best testimony as to the success of the schools. Men who had been planning and installing wiring and lighting systems for many years testified that never before had they understood the fundamentals of good lighting practice and that they would in the future use in all their work the knowledge gained in the classes. R. W. Clark, who acted as chairman of the committee conducting the Seattle school, and Lewis A. Lewis, chairman of the Spokane committee, both report their schools as huge successes and recommend that something be done to carry on this work, and that similar schools be arranged for each year.

The committee believes that an improved standard of lighting practice will be reflected in the work done through these schools and recommends that during the coming year a lecture and demonstration, prepared by Mr. Baker for presentation to business men through civic clubs and organizations, be presented through a speakers bureau of the lighting committee, so that business men may gain an appreciation of the fundamentals of good lighting, thus making it easier to sell good lighting installations to them.

Street Lighting*

Summary

This report sets forth the general outline of the work of the national street lighting committee as well as the local committee. It then discusses various characteristics of the street lighting load, such as load factor, income per kilowatt year, location of the street lighting load with respect to the daily and system load peak, the advertising value of street lighting, the possibilities of increasing the present load and the prevalent methods of financing these systems. Its conclusion is that there is a large field for the development in this load, and that the load is on the whole a very desirable type to encourage.

Scope of the Committee Work

The street lighting committee of the N.E.L.A. early in its year's work decided that there was urgent need for a study to be made that would convince commercial department executives that the street lighting load was a desirable form of central station load; that it had large possibilities for immediate development; and that it should be actively solicited. In addition to this study, it was felt that an analysis should be made of the present methods of financing both the installation and the operation and maintenance of the systems. In presenting the results of these studies, it was felt that a report should also be made showing sales methods that had proved to be satisfactory and recommending certain approved modern forms of street lighting contracts.

This, it will be admitted, was rather an ambitious program and the committee decided that the work should be extended over a three-year period, with the issuance of progress reports from time to time.

The Northwest committee decided to follow a somewhat similar course and for the first year's work undertook to collect data which would show the value of a street lighting load and therefore the desirability of securing it.

To determine whether such a load is desirable or not, its characteristics should be known, also its net revenue and the relative cost per kw. to secure it. A questionnaire was sent to each member of the committee asking certain pertinent questions along these lines. From the nature of the returns, it would seem that some of the data was apparently not readily available. Nevertheless, a start has been made and the committee believes enough data has been secured to provide a visualization of some of the possibilities of this type of load.

Characteristics of Street Lighting Load

A street lighting load has certain characteristics which are practically universal in their nature. It is a load that comes on every day with the regularity of the sun, it is non-fluctuating in character, it continues for a large number of hours each day, it is not affected by business conditions, and it has a seasonal variation which changes very slowly in kw-hr. consumption, and not at all in regard to demand, except for periodic increments as new business is acquired.

The high intensity lighting districts as a rule discontinue from one-half to two-thirds of the load at midnight or one a.m., leaving the balance on until daylight. Nevertheless, the general overhead street lighting load which constitutes the bulk of street lighting load of the country at the present time remains on from dusk to daylight, which in this part of the country gives an operating period of about 4,100 hours out of a possible 8,760 hours per year. The entire street lighting load, therefore, comes on about dusk and continues steadily until about midnight when a portion of the high intensity district load is dropped and the balance continues until daylight throughout the lowest valley period of the daily load. The street lighting load as a whole increases from time to time throughout the year and practically never decreases in any amount.

Load Factor of Street Lighting Load

The seasonal load factor of street lighting for this district ranges from 41.8 per cent to 47.2 per cent with a weighted average of about 44.3 per cent. This needs no further elaboration since no other class of load is even a close competitor although it is known that individual loads may frequently exceed this percentage. Another feature of the street lighting load is the fact that the demand is 100 per cent of the connected load.

Income per Kilowatt-Year

From the data shown in Table I, it may be seen that the rates per kw-hr. charged for this service range from 2c to 4.42c per kw-hr. for bus bar energy, the higher rates occurring in the smaller cities where costs for service are naturally greater. Rates for energy are lower in most cases than for either residential or commercial light, but higher than those received for power. However, the load factor of the street lighting load is generally higher than that of the other classifications and it would be interesting to know where street lighting stands relative to revenue per kilowatt-year, as compared with similar data for the other classes of service.

Accordingly, data were prepared from information contained in the questionnaire showing the returns per kilowatt-year for energy for street lighting. As may be seen, this ranges from $59.79 per kilowatt-year to $178.11 per kilowatt-year, giving a weighted average of $88.50 per kilowatt-year. Complete data are not available at this time to show the return per kilowatt-year for other classes of lighting service for these same properties, but the demand and monthly kw-hr. consumption were taken from twelve typical commercial lighting customers and from twenty typical power customers of one of the central stations of this district and the rates of different cities applied to the

* **F. H. Murphy,** Portland Electric Power Company, chairman. **Eastern Oregon Light & Power Company:** A. C. Wright. **Idaho Power Company:** G. H. Davis. **Northwestern Electric Company:** D. F. McCurrach. **Pacific Power & Light Company:** George T. Bragg. **Utah Power & Light Company:** R. H. Ashworth. **The Washington Water Power Company:** G. H. Pike.

TABLE I—Street lighting data, Pacific Northwest District.

	Cities Grouped by Population					
	Class I—Over 200,000		Class II—50,000 to 200,000	Class III—Under 50,000		
1. State briefly methods used in securing street lighting load..	Work with local booster clubs. Make estimates of installation and maintenance costs.....	Assist paid solicitors in securing signatures from property owners for an improvement district.....	Assist the merchants in promoting white way lighting...	No special effort except to offer good rates.	Work with local clubs. Prepare cost estimates.....	Continuous work with customers and city council.
2. What is usual type of street lighting unit used?.....	Series Magnetite arcs and incandescents for overhead. Series incandescent for ornamental and white way lighting.....	Incandescent ornamental standard.....	Series Incandescent pendants in outlying districts. Luminous arcs in business districts..	Incandescents on brackets in residential districts. Ornamental standards in better business districts.....	Both series and multiple overhead incandescents. Incandescent ornamental standards in higher class business districts.....	Novalux pendant units. Incandescents.
3. Ornamental street lighting system:						
By whom owned?.....	Property owners	Property owners	75 per cent property owners 25 per cent City	Property owners	.....	Municipality
By whom maintained?..	Property owners	Property owners	75 per cent property owners 25 per cent City	Property owners	.....	.....
4. General overhead street lighting system:						
By whom owned?.....	Power company	.....	Power company	Power company	.....	Power company
By whom maintained?..	Municipality	.....	Municipality	Municipality	.....	Municipality
5.(a) Kw. load "dusk" to "daylight" (all night).....	2,042	114	920	707	70	488
(b) Annual burning hours.	4,098	4,098	4,140	4,000	4,000	4,080
6. (a) Kw. load "dusk" to "midnight" only.....	217	237	000	000	1.5	80
(b) Annual burning hours.	2,450	2,448	000	000	2,000	1,425
7. Annual load factor—street lighting.....	44.9	34.1	47.2	46	46	41.8
8. Annual load factor:						
(a) Residential.....	000	5.1 per cent	000	000	000	000
(b) Commercial.....	000	9.0 per cent	000	000	000	000
(c) Power.....	000	20.0 per cent	000	000	18 per cent	000
9. Street lighting revenue per kw-hr. for energy only; measured at bus bars.....	$ 0.02	$ 0.02	$ 0.02	$0.035*	$0.0442*	$0.0213
10. Gross street lighting revenue per capita.....	$ 0.65	$ 000	$ 0.60	$ 0.88	$ 0.78	$1.29
11. Gross revenue per kw-hr.:						
(a) Residential.....	$0.0482	$0.0335	$0.043	$0.0528	$0.109	$0.050
(b) Commercial.....	0.0380	0.0302	0.029	0.0661	0.082	0.021
(c) Power.....	0.0180	0.01513	0.000	0.0187	0.029	0.011
12. New business cost per kw.:						
(a) Residential.....	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000
(b) Commercial.....	000	000	000	000	000	000
(c) Power.....	000	000	000	000	000	000
(d) Street lighting.....	000	000	000	000	000	000
13. Revenue for energy per kw-yr.						
(a) Street lighting.....	$ 69.94	$ 59.79	$ 82.80	$141.04	$178.11	$ 78.94
(b) Commercial.....	79.67	79.67	79.15	000	000	000
(c) Power.....	44.62	44.62	47.64	000	000	000

*Cost submitted was based upon lamp wattage, and has been corrected to bus bar value assuming a distribution and transformation loss of 20 per cent of lamp wattage.

single set of conditions. The demands for commercial customers ranged from 0.63 kw. to 20 kw.; and for the power customers from 1.3 kw. to 2,858 kw. In each case the number of small demand customers predominated as is the condition with the actual accounts of central stations generally.

These calculations while not representative of actual conditions, may, it would seem, be considered reasonably indicative of the returns per kilowatt-year for commercial lighting and power loads. Any discrepancy in these figures would be in the direction of a higher load factor and a higher return per kilowatt-year than actually exists for commercial and power accounts, for it is lamentably true that the customer almost invariably increases his demand upon the system after it has been originally determined. The load factor and the return per kilowatt-year are therefore both higher than should be in all cases except for large loads where accurate check is kept on the demand. Such is not true, however, or these same values for street lighting loads, for here no increase in load is made without the knowledge of the utility and the revenue is increased in direct proportion. Notwithstanding these known discrepancies, the load factor and revenue per kilowatt-year for street lighting loads make a very favorable comparison.

In view of these conditions, it is believed that most of the utilities would be quite willing to dispose of a large part of their output in blocks as large as their street lighting loads and to customers whose credit is as satisfactory as that of their street lighting customers at rates per kilowatt-year that are certainly no greater than they are now receiving for street lighting.

Street Lighting Load and System Peaks

Another feature that must be given consideration is the manner in which the street lighting load overlaps, or coincides with, the daily and seasonal peaks.

In one of the largest cities of this section, the daily system peak from about Oct. 1 to March 1 occurs between 5 and 6 p.m.; from March 1 to Oct. 1, the daily system peak occurs about 10 a.m. Referring to the street lighting load curve (Fig. 2) it will be seen that during the months of November to February, inclusive, the street lighting load will coincide more or less with the daily system peak. During the month of December occurs also the seasonal daily peak of those utilities lying west of the Cascade Mountains or of those not having a very large irrigation load, and this at a time when it coincides with the street lighting load.

It is seen, therefore, that this load is one that draws upon the plant at the same time that the seasonal peak of the system makes its demands. On the other hand, the street lighting load, in itself, is no greater in December, barring the normal growth, than it is in June or July, nor is it any greater at 6 p.m. than it is at 11 p.m. In fact, this load does not change in value from the time it is turned on at dusk until it is turned off at daylight, except for a small amount of load that is lost at midnight due to a decrease in illumination in the brightly lighted districts.

The time of day when the street lighting load occurs is such that its importance cannot be overestimated. Almost the entire load falls in the night valley period of the daily load curve. This is a period that all central stations desire to fill as much as possible

and frequently special rates are offered to encourage use of energy at this period. Here is a load which naturally falls in this valley period and needs no special inducement to assure its use at that time. The situation calls for sales activity in this field, not rate changes, in order to add materially to the valley load.

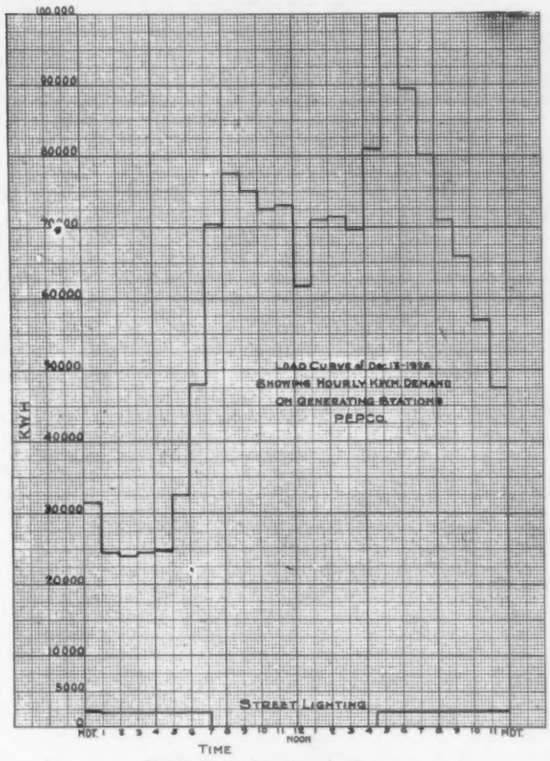


Fig.1. Typical system load curve.

It is perfectly evident, therefore, that the street lighting load is not a peak type of load at all, and that the seasonal peak as well as the daily peak are consequently dependent upon other classes of loads for their existence.

Investment and New Business Costs per Kw. of Load

Thus far the committee has been unable to determine what the central station investment per kw. of demand for street lighting load might be, nor has it been any more successful in determining the same value for other classes of service, although this comparison is desirable in a complete discussion of the relative values of different types of load. It is quite possible that for general overhead street lighting systems the investment per kw. of load is greater on the average than for other types, whereas for the intensive white way district it should be less.

An endeavor was made to determine the cost per kw. for securing new business for the different classes of load in order that it might be determined whether the cost of securing street lighting load was at all comparable with the amount spent to secure other classes of loads. Apparently the majority of the utilities keep little data of this character, as so little information was received that it has been omitted from the tabulation. It would seem evident, however, from the answers to the question regarding what methods were used to secure new street lighting business, that the cost per kw. of new load of this type is not at present large.

Advertising Value of Street Lighting

Does street lighting have any other value to a central station than as a direct load with a good load factor? The committee believes that it has a very appreciable advertising value. For example: When a stranger comes to a city, his impression of the character of that city is frequently determined by the lighting of its streets. How often have you found yourself thinking that this place has well-lighted streets, and that it must be a live town; or that this other place has such poor lighting that you can scarcely get about the streets at night so that you instinctively feel that the town must be dead? However, do you, or does the average citizen, place the criticism upon the city council? Almost invariably

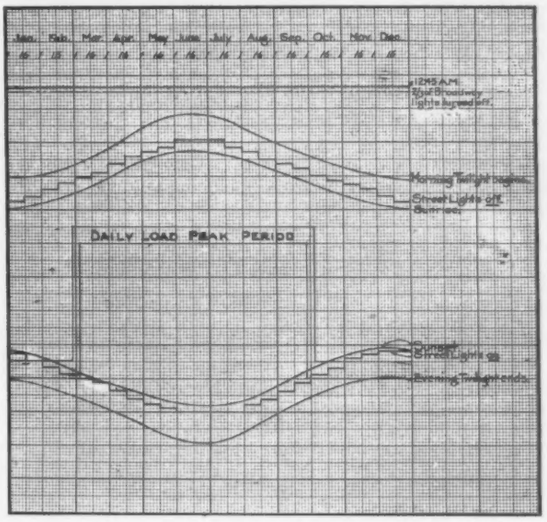


Fig. 2. Street lighting schedule.

not. The praise or the blame is placed upon the central station, and there is no service that the company renders that so impresses itself upon the whole public as its street lighting. Such an important advertising medium is certainly worthy of proper cultivation.

No attempt is made at this time to discuss the advantages to the city as a result of improved street lighting. Such a discussion falls within the scope of work of a future street lighting committee when sales arguments will be presented. It is evident, however, that these advnatages such as the reduction of crime and accidents, the speeding up of traffic with safety, the enhanced property values, and the arousing of a greater civic pride, all assist in attracting permanent

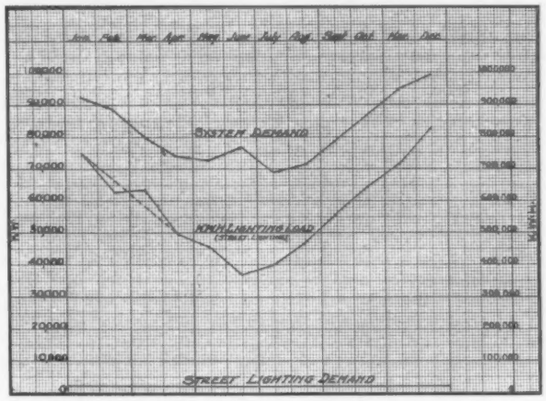


Fig. 3. Comparison of load demands.

residents and business to a community, which in turn result in direct increases for all classes of central station service.

Is Street Lighting Load Near Saturation Point

Finally the question arises as to whether there is much of a field for increasing the present street lighting load, or whether we are near the saturation point.

A. F. Dickerson, illuminating engineering laboratory, General Electric Company, in a paper about six years ago discussed the average cost of street lighting per capita for the United States. He found that in 1919

for 227 cities, with populations over 30,000, the average cost was 72 cents per capita, and in 747 cities of over 5,000 population, and under 30,000, the average was found to be 71 cents per capita. It is generally conceded that the street lighting of the country as a whole is below par, and that even at that item it was recommended that the average per capita expenditure for the municipality should be not less than $1 per capita; yet there were only nine cities, spending over 90 cents and only four that exceeded one dollar.

Mr. Dickerson found that the larger cities, except in the case of very large ones, were spending more money per capita for street lighting than the figures just quoted. He found that the average for the fifty best lighted cities was $2.04 per capita, some cities reaching as high as $4.81. Since the time of this report, however, cities have been increasing their lighting and there is a general improvement throughout the country in all sizes of communities from the small city to the large one.

Referring now to the table of street lighting data, it may be noted that the costs per capita range from 60 cents to $1.29, and the average is well under $1.

Let us consider for a moment what is happening in the larger cities of the country. We find them vying with one another for higher and higher intensities on their main streets and thoroughfares. Within the past eight or ten years, each of the larger Western cities and many of the Eastern ones have lighted one or more of their main streets with high intensity lighting—each a little better than the preceding one. Finally, about eighteen months ago, when Portland lighted up Broadway, it was heralded as the brightest street in America, but in less than a year State Street, Chicago, blazoned forth with three times as much light per square foot of street as Broadway, and yet State Street is not too bright for its needs.

In fact, we haven't yet started to light our streets. We are just beginning to realize the real value and necessity of better lighting on both streets and highways, and the future is rich with possibilities.

Financing of Street Lighting Systems

A full discussion of the financing of street lighting systems will not be undertaken at this time. Nevertheless, from the data collected in this district, it would appear that the property owners in the intensive street lighting district pay for all or a majority of the installation cost as well as the maintenance cost for the system for at least an initial period of years. This has the advantage of relieving the central station from a large investment.

While the property is now carrying the maintenance of the system, there seems to be a growing feeling that good lighting even in the business sections is a direct benefit to the entire city, and that after an initial five or ten-year period, the city should assume the expense as a general obligation. There would appear to be a great deal of merit in this idea and it will probably win out eventually.

Conclusion

This committee believes that its study has shown that the character of street lighting load is desirable; that the return per kilowatt-year is satisfactory; that the investment per kw. of load is reasonable; that the advertising is valuable; and that the field for development is large. This is a time when such a character of load is almost selling itself in many communities and the cost of obtaining it must therefore be slight in comparison with other new business costs. If these conclusions are correct, it would seem that the time had arrived for central stations actively to enter this field.

Rural Electric Service*

This committee is pleased to report that great progress has been made during the past two years in the investigations looking toward wider uses of electricity on the farm. These studies have been carried on in a number of states in the territory represented by this association. The investigations are well organized and are accomplishing excellent results.

The committee has acted as a point of contact between the Northwest Electric Light & Power Association and the state officers and organizations who are engaged in the research work. The committee itself has not carried on any field work, but has assisted other agencies. Therefore this report will, to a large extent, cover the activities of the agencies that did the work.

State Investigations—Oregon

The Oregon committee, in co-operation with the National Committee on the Relation of Electricity to Agriculture, issued its 1926 report since the last convention. This report was prepared by Geo. W. Kable, project supervisor for the committee, who is devoting a great deal of energy to the work in hand. A similar report was issued in 1925. The 1926 report is much more elaborate and gives the results of more field work. In his report on progress Mr. Kable covers such activities as irrigation by electric pumping, including the application of water to many crops such as hops, potatoes, corn and other produce. He also discusses the use of electricity in the poultry business, in horitculture for dehydrating, and also in the rural home. Mr. Kable devotes most of his attention, however, to the general use of electricity on the farm. The program for Oregon investigations for 1926-27 includes the use of electricity in truck gardening and pastures in the Willamette Valley and in the coast counties. It includes also experimentation at the Oregon Agricultural College in the poultry and dairying industries. It is believed by Oregon authorities that one of the most important factors in connection with the use of electricity on the farm is that of general farm use rather than for the more specific application. This committee feels that the investigations being carried on by the authorities in Oregon are comprehensive and painstaking and should have the support of our association.

Washington

The situation in Washington with respect to investigations being made by the agricultural experiment station is much the same as in Oregon. Edward C. Johnson, director of the experiment station at Washington State College, Pullman, is enthusiastically interested in the matter of further development of rural uses of electricity. The Washington Committee on the Relation of Electricity to Agriculture is co-operating with the experiment station. The experiments cover a number of important matters, including pumping, spraying, poultry production and domestic and general uses of electricity on the farm. One of the notable increases, to our knowledge of the subject, is General Bulletin 212, issued in February, 1927, entitled "The Stationary Spray Plant," by Harry L. Garver, investigator for the Washington committee. This is a very comprehensive publication and summarizes the best knowledge on the subject. There is no doubt but that the stationary spray plant will ultimately become a large user of electrical energy.

Idaho

In April, 1927, the Idaho Committee on the Relation of Electricity to Agriculture presented its second progress report. This is a very comprehensive document and should be read by all those interested in the activities of this and similar committees. The committee is making a careful investigation of the electrification of the Caldwell farm, which is a substation of the Idaho agricultural experiment station. The committee is also running a test on the utilization of electrical energy for silo operation, and is making an investigation covering a comparison of oil and electricity for incubators.

By far the most interesting part of this report is that printed under the heading "Cost of Distribution

* **Report of special committee.—L. A. McArthur,** Pacific Power & Light Company, chairman. **George T. Bragg,** Pacific Power & Light Company, vice-chairman. **The California Oregon Power Company:** J. C. Thompson. **Deschutes Power & Light Company:** L. R. Sheeley. **Mountain States Power Company:** H. C. Wells. **Portland Electric Power Company:** A. C. McMicken. **Puget Sound Power & Light Company:** L. R. Grant.

of Electrical Energy by Mutual Companies on the Minidoka Project." This study was made for the purpose of ascertaining the real cost of electrical energy to the farmer and not simply the cost as reflected in the monthly bills. The committee studied three mutual companies which have been in operation between four and one-half years and eight years. The investigators found that the mutual companies were losing through distribution losses approximately one-half of the kilowatt-hours purchased at the government substations, and that the rates charged the consumers included no allowances for depreciation, taxes, interest on the distribution investment, and no allowance for deferred maintenance. Perhaps it would be best to reproduce the conclusions reached by Professor M. R. Lewis who made the investigation. They are as follows:

Investigation of Mutual Companies

"From the data herein given it will be seen that the real cost of distribution of electric energy is only partially reflected in the rates charged by the mutual companies. The rates for the three companies under discussion are as follows: East End Mutual Electric Company, minimum charge of $1.50 per month for which 25 kw-hr. are delivered, next 100 kw-hr. at 3c, and all over 125 kw-hr. 1c; Unity Light & Power Company, minimum charge $2, for which 50 kw-hr. are delivered; next 50 kw-hr. at 3c, next 50 kw-hr at 2c; and the excess at ½c; Riverside Electric Company, service charge of $1 per month plus 3c per kw-hr. for all energy used.

"It will be asked how these companies are able to operate under the rates given if such rates do not cover the actual cost. There are several reasons for this. The farmers supply the capital necessary for the construction of the system and get no return on this investment. The cost of transformers, meters and services is also borne by the consumer, thus neither the original nor the upkeep cost of these items appears in the company costs. An exception to this last statement is that the companies look out for ordinary maintenance of the transformers. As noted above most of these companies make no provision for replacement of distribution lines when the poles fail. As these companies were organized and the system, in the main, built in 1918 and 1919, the pole lines have just reached the point where failures are becoming numerous. For this reason the lack of a replacement reserve is just beginning to be felt. It seems doubtful if any of these companies can replace their lines as necessary without recourse to higher rates or stock assessments.

"If the cost of the electric service by these mutual companies is to be compared with that by public utilities certain further points must be considered. The investment made by a public utility must earn a reasonable reutrn or the company will find itself unable to secure funds for necessary extensions or enlargements. It is therefore necessary for the utility rates to be high enough to insure such a return. In the case of the mutual companies no return is expected to be made on the investment and therefore no provision for earning it is made in the rates.

"The investment in distribution lines, per mile of line, by these companies is very low. Several reasons account for this. The farmer consumers furnish some labor in building the lines particularly in transporting materials and in digging holes and setting poles. On the mutual companies this labor is donated and therefore does not appear in the costs. Such donations of labor are not received by the public utility. Rights of way are either secured by franchise over county roads without cost or are donated by landowners. The time and effort put in by the farmer promoters themselves in organizing the companies and in securing the co-operation of the other members is not paid for. These items account for a material difference in the investment per mile of line.

"A large part of the difference is due to the higher standards of materials and construction maintained by public utilities. It is probable that the poorer construction of the mutual company lines is reflected in higher maintenance and replacement costs. The final result is probably a greater cost of service by the mutual companies on this account. The fact that the mutual companies do not furnish transformers, meters and services has been stated above. Since the cost of these items will run from $400 to $600 or more per mile the effect on rates will be ovious.

"Taxes are another item of cost which enter very largely into the rates of the commercial public utilities. The mutual companies being organized as non-profit corporations are not required to pay taxes on their investment. The immediate result is, of course, a reduction in their operating cost as compared with that of a commercial organization. Whether this reduction of cost to the consumer of electric energy is a real one or not will depend chiefly on the proportion of the tax payers who are receiving electric energy. Either (A) a portion of the taxes of a taxing unit may be assessed against the electrical utility and passed on to the consumers in the form of charges for electric energy, or (B), the utility may pay no taxes and all of the revenue of the unit may be collected directly from the other taxpayers. If all the taxpayers in the unit receive electric energy and receive it in the same proportion that they pay taxes, it will make no difference in the ultimate cost to them which of these plans is used. Such a condition will never be realized. Under all ordinary conditions whatever taxes are remitted to electric utilities, or, what is equivalent, are not assessed against such utilities, will necessarily become an added burden to all other taxpayers. Just what benefits accrue to an individual who is both a taxpayer and a consumer of electric energy under each method depends on a large number of factors.

"In the ordinary case, the utility extends into more than one taxing unit, has consumers in each unit who are not direct taxpayers and does not serve all the taxpayers in any unit. It will be evident here that any relief in the matter of tax payments to the consumers as a whole or to any group of them will necessarily increase the tax burden of the balance of the community. A similar result is reached in a case in which a portion of the industry, such as the mutual and municipal electric companies, are not assessed for taxation, and the balance, such as the public utilities, are so assessed. Here the tax burden on the consumers from the public utility as well as on all other taxpayers of the state is perforce enough greater to make up for the tax which would otherwise be paid by the mutual and municipal companies."

California

California presents an unusually attractive field for the development of the rural load for central stations. To a certain extent this is due to the large pumping load which is sufficiently remunerative to cause the construction of many miles of rural lines that otherwise could not be built. This has carried electric service into hundreds of square miles of agricultural territory. The California committee, working in conjunction with the state experiment station and the University of California farm at Davis, has a comprehensive program of investigation. This is being done under the direction of Ben D. Moses, executive secretary of the California committee. At the present time the California experiment station has in hand material for the following bulletins, some of which will doubtless be published by the time this report is read:

1. Electric brooder
2. Standard pump agreement
3. Rural electric statistics
4. Electric dairy sterilizer
5. Documents on water heater tests
6. Dehydrating
7. Vacuum cleaner tests
8. Effect of sterilizers.

The results of all these experiments and tests will be published during the summer of 1927. Some of the investigations have been in hand for more than two years.

California's Poultry Industry

This chairman spent ten days in investigating the rural service situation in California and is more enthusiastic than ever over the possibilities of increase in loads of different character. In the poultry business alone the possibility of future load is very large. As an example, attention is called to the fact that on September 12 when a chicken hatchery at Petaluma

TABLE II—Northwest Electric Light & Power Association Rural Customer & Distribution Line Survey as of December 1, 1926.

	Oregon				Washington				Idaho				Montana				Utah			
	Customers				Customers				Customers				Customers				Customers			
	As of 12-1-26	Added 1926	Per Cent Farmers	Miles Rural Line	As of 12-1-26	Added 1926	Per Cent Farmers	Miles Rural Line	As of 12-1-26	Added 1926	Per Cent Farmers	Miles Rural Line	As of 1926	Added 1926	Per Cent Farmers	Miles Rural Line	As of 12-1-26	Added 1926	Per Cent Farmers	Miles Rural Line
Eastern Oregon Light & Power Company	376	101	50	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prairie Power Company	18	2	100	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portland Electric Power Company	3,233	696	100	417	195	9	100	20	0	0	0	0	0	0	0	0	0	0	0	0
Mountain States Power Company	1,464	400	90	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Molalla Electric Company	247	65	90	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
California-Oregon Power Company	1,014	61	65	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington Water Power Company	0	0	0	0	2,491	200	80	680	209	20	80	46	0	0	0	0	0	0	0	0
Grays Harbor Ry. & Light Company	0	0	0	0	122	25	10	5	0	0	0	0	0	0	0	0	0	0	0	0
Willapa Electric Company	0	0	0	0	123	24	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Northwestern Electric Company	24	10	100	9	1,105	210	100	145	0	0	0	0	0	0	0	0	0	0	0	0
Mount Spokane Power Company	0	0	0	0	184	36	72	43	0	0	0	0	0	0	0	0	0	0	0	0
Puget Sound Power & Light Company	0	0	0	0	35,000	500	90	2,901	0	0	0	0	0	0	0	0	0	0	0	0
Pacific Power & Light Company	1,947	248	79	210	4,795	1,026	74	620	204	16	44	60	0	0	0	0	0	0	0	0
Idaho Power Company	0	0	0	0	0	0	0	0	5,182	711	92	800	0	0	0	0	0	0	0	0
Northwest Light & Water Company	0	0	0	0	0	0	0	0	35	5	0	5	0	0	0	0	0	0	0	0
Kootenai Power Company	0	0	0	0	0	0	0	0	0	0	100	7	0	0	0	0	0	0	0	0
Salmon River Power & Light Company	0	0	0	0	0	0	0	0	11	0	5	2	0	0	0	0	0	0	0	0
Potlatch Consolidated Electric Company	0	0	0	0	0	0	0	0	5	0	0	0	480	28	25	53	0	0	0	0
Missoula Public Service Company	0	0	0	0	0	0	0	0	0	0	0	0	160	7	75	31	0	0	0	0
Helena Light & Railway Company	0	0	0	0	0	0	0	0	0	0	0	0	300	60	50	150	0	0	0	0
Montana Power Company	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	4	90	10
Western States Utilities Company	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	7	100	65
Dixie Power Company	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,743	596	74	821
Utah Power & Light Company	0	0	0	0	0	0	0	0	1,806	328	97	351	0	0	0	0	10,856	607	0	896
Totals	8,303	1,582	0	1,077	44,015	2,030	0	4,417	7,512	1,080	0	1,291	940	95	234					

No data were received from the municipally operated electric utilities at Seattle and Tacoma, Washington, and Eugene, Oregon. However, the Seattle and Tacoma distribution systems are presumed not to reach beyond the city boundaries which precludes rural patronage. It has been reported upon good authority that the City of Eugene served approximately 600 rural customers of which 50 per cent are estimated to be farmers, all receiving service under 32 miles of rural distribution line.

Member Companies Not Reporting

Hermiston Light & Power Co., Hermiston, Ore.
Vale Electric Company, Vale, Ore.
Sultan Electric Co., Sultan Wash.
Cheney Light & Power Co., Cheney, Wash.
Northwestern Power & Light Co., Port Angeles, Wash.
Stevens County Power & Light Co., Spokane, Wash.
Union Electric Company, Dillon, Mont.
Baker Light & Power Co., Baker, Mont.
Wood River Power Company, Hailey, Idaho.

began the season, 169,000 chicks were popped into the world at the plant of the Must Hatch Incubator Company. Over one thousand visitors from all over the state were on hand at the hatching. This particular hatchery is operated by electricity furnished by the Pacific Gas and Electric Company, and during the three spring months turns out approximately 1,850,000 chicks every three weeks. The total California output of chicks during the year 1927 is expected to be 50,000,000. California's poultry production in 1926 was valued at nearly $75,000,000, and Petaluma's share in this production was more than $18,000,000.

The chairman was informed by those in touch with the business that the continuity of service now furnished to the rural sections of the state is such as to remove any doubt on the part of the chicken producers as to the possibility of damage from the failure of power on the lines.

Professor Moses published an interesting article in the March number of Electrical West on "Electric Brooders," which should be called to the attention of those individuals in the organizations of our member companies who have to do with rural service. Professor Moses' investigations may be summed up as follows:

Summary of Brooder Investigation

Professor Moses estimates that there are between 1,000 and 1,500 electric brooders in use in California. He estimates that 1,000 brooders are producing a revenue to the central stations of $20,000 a year. He also estimates that there are at the present time potential markets for from 5,000 to 10,000 brooders in the state, and that if the latter mark is ever reached the energy used for brooding will produce $200,000 a year in gross revenues for the utilities. Incidentally this load is attractive because it comes on at the time of the year when ordinarily loads are low.

Following are the salient features of Professor Moses' published statements about electrical brooders:

1. There are two methods of heating with electricity; one depends upon convection or conduction or both, using either black heat or glowing elements, while the other depends for its heat upon radiation from glowing elements.

2. The ventilation problem is of great importance, especially is this so in cold or humid climates.

3. The brooder room or house must itself receive careful thought. A south exposure on a sunny slope, protection from the wind, tight or well insulated walls and a well-designed ventilation system are all important helps to satisfactory brooding.

4. Proper space should be provided; 7 sq. in. per chick is generally considered to be the minimum, unless the brooder is a room heater in which case this area may be modified.

5. A connected load from one to two watts per chick and an energy consumption of from one to three watts per chick per hour seems reasonable.

6. Thermostatic control insures uniform temperature and should be installed.

7. Either the plain convection or the radiant type have very little heat storage capacity rendering power interruption hazardous, while the floor-heated and some of the heavier wooden curtained brooders may be able to tide over short interruptions, with little or no bad effects.

In making its study, the California Committee on the Relation of Electricity to Agriculture installed meters on twenty-six brooders and took readings of power, temperature and mortality. The accompanying condensed table shows the findings:

TABLE I—Results of two years' observation of electric brooders.

	Convection Type	Radiant Type
Total chicks placed under brooders	21,940	10,874
Total chicks turned out	18,121	9,394
Total power required to heat brooders	8,596.9 kw.-hr.	13,824 kw.-hr.
Total connected load	28,467 watts	20,376 watts
Average time for brooding	1,006 hours	1,209 hours
Per cent time power on	30.2 per cent	56.1 per cent
Average connected load per chick put under hover	1.29 watts	1.87 watts
Average consumption per chick turned out	.47 kw.-hr.	1.36 kw.-hr.
Average consumption of energy per chick turned out per hour	.467 watt-hr.	1.125 watt-hr.

Wide Field In California

The rural electrical business in California has assumed very large proportions and some idea of the extent of the rural uses of power in the state may be gathered from figures submitted by two utilities.

At the end of 1925 10,057 agricultural power consumers of Pacific Gas and Electric Company had a connected load of 195,552 hp., and during the year they consumed 122,176,318 kw-hr. This was about 9 per cent of the company's kw-hr. output. These statistics show power consumers alone and do not include lighting.

There was a very substantial increase in the same figures for 1926. The number of power consumers had then reached 11,104, with connected hp. of 206,302. The kw-hr. consumption showed an increase of about 30 per cent and in 1926 amounted to 158,323,493.

In 1924 the Southern California Edison Company had a connected load of 168,872 hp. in irrigation pumping plants. This connected load was increased to 197,471 hp. at the end of 1925. This is an extraordinarily large increase. This committee has not been able as yet to secure the corresponding figures for 1926, but it is understood that these will show a proportionate increase. Southern California Edison Company reports the delivery to customers' meters for use in agriculture of 18.8 per cent of its total sales.

Legislation and Orders

It does not appear that any of the state authorities of the states covered by this report issued new or changed rules or regulations with respect to rural line extensions. It is believed that the extension rules and regulations are generally satisfactory.

The California Railroad Commission recently approved new rules for the San Joaquin Light & Power Corporation which are of interest to our association, for the reason that these rules are not based upon the cost of a line expressed in money, but on the length of line expressed in feet. The free extension to be made by the company, including all equipment up to the entrance block, is as follows:

For each lighting customer	100 ft.
For each kw. of connected heating or cooking load	75 ft.
For each hp. of power load in installations of less than 5 hp.	75 ft.
For each hp. of connected power load in installations of 5 hp. or over	100 ft.

The company will build lines only on public highways and satisfactory private right-of-way and the rest of the line is to be computed from the nearest distribution pole to the point of connection of customer's service along the shortest practicable route, even though trees or over railroad crossings. Beyond the free length as provided for above, the company will build and maintain lines for 25 cents a ft.

Advance payments are to be refunded for a period of not to exceed ten years, at the rate of 10 per cent of the annual bills for all customers for whom the line was built. For additional equipment metered separately from the equipment for which the line was built, a table of additional refunds has been worked out, the basis of which is $25 for each lighting customer and $10 for each horsepower of additional connected load. Refunds will be made in chronological order to customers who have previously made advances for construction and refunds for additional or subsequent extensions will be made only after advance on previous extension necessary to supply service to subsequent extensions have been paid in full. Refund to two or more customers will be made in proportion to the advance payment of each. It is reported by the San Joaquin company that this line extension policy is quite successful and satisfactory.

Decision Of Federal Tax Board

One interesting decision is called to the attention of the association. On June 21, 1926, the U. S. Board of Tax Appeals said, in re Liberty Light and Power Company, Richmond, Ind. (29 Rate Research p. 83), that contributions paid by rural residents to induce a company to extend its service could not be held to be taxable income. The commissioner of internal revenue had previously held that they constituted taxable income.

Census

During the year this committee prepared a census of rural customers on distribution lines for five states in the Pacific Northwest. The results of this census are incorporated in this report. Attention must be called to the fact, however, that at least two of the company reports contained in this census are said to be in error. The extent of such error, if any, is not known by the committee, but the committee is informed that the figures of The Washington Water Power Company are of 1925 rather than 1926, and that the figures for the Puget Sound Power & Light Company are estimated and not actual.

Conclusion

This committee strongly urges that all members of the association study carefully the points brought out in this report. There is no doubt that there is a good opportunity to develop good will, better customer relations and better economic conditions generally by closer attention to the possibility of a greater use of electricity in agriculture. The committee feels that each member company of the Northwest Electric Light & Power Association should study the situation existing in its territory to see if there are any latent possibilities.

Engineering Section Committee Reports

Executive*

The executive committee of the Engineering Section during the past year held five meetings: Portland, Ore., Sept. 13, 1926; Seattle, Wash., Nov., 5 and 6, 1926; Spokane, Wash., Jan. 7-8, 1927; Portland, Ore., March 10, 1927; Seattle, Wash., April 14-15, 1927.

National Group Meetings

Delegates were sent to the group meetings of the Engineering National Section as follows: O. L. Le Fever, D. W. Proebstel and C. C. Simeral to group meeting held at Edgewater Beach Hotel, Chicago, October 13, 14 and 15, 1926; E. F. Pearson and D. W. Proebstel to group meeting held at national headquarters, New York, on February 2, 3, 4 and 5, 1927.

F. J. Rankin of the Idaho Power Company was appointed chairman of the executive committee at the beginning of the association year, but because of his transfer to New York City he resigned and was replaced by O. L. LeFever of the Northwestern Electric Company, Portland.

The most important matters given study and consideration by the committee will be recorded under headings as follow:

Revision of General Order Number 10, State of Idaho

Revision of overhead systems rules for the State of Idaho, known as General Order No. 10, was discussed and analyzed at considerable length at the Spokane meeting. The committee finally decided that if General Order No. 10 was to be changed at all, Part 2 of the National Code should be substituted. Z. E. Merrill, chairman; H. H. Schoolfield, J. B. Fisken and T. A. Purton constituting a committee form the Engineering Section, attended the hearing held at Boise January 11, 1927. The final hearing is set for June 27, 1927.

High-Tension Testing Laboratory

Work of the Engineering Section for the past two years has brought out the need for better high-tension testing facilities than now exist at any point in the Northwest. The Oregon Agricultural College at Corvallis, under the auspices of the overhead systems committee, is conducting tests on high-tension insulators and high-line insulator-handling tools. Due to the present close tie-in of this institution with the section and to its possession of a larger amount of

* **O. L. LeFever,** Northwestern Electric Company, chairman. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Grays Harbor Railway & Light Company:** W. S. Hill. **Idaho Power Company:** T. A. Purton. **Mountain States Power Company:** Z. E. Merrill. **Northwestern Electric Company:** E. F. Pearson. **Pacific Power & Light Company:** H. H. Schoolfield. **Portland Electric Power Company:** C. P. Dunn, D. W. Proebstel, C. C. Simeral. **Puget Sound Power & Light Company:** G. E. Quinan, R. E. Thatcher. **Utah Power & Light Company:** J. A. Hale. **The Washington Water Power Company:** J. B. Fisken.

high-tension testing equipment than exists at other schools, the college was considered the most logical place for a high-tension testing laboratory for general use throughout this geographic section. In accordance with this conclusion a committee consisting of J. B. Fisken, Z. E. Merrill, H. H. Schoolfield, T. A. Purton, C. P. Osborne and O. L. LeFever, conferred with W. J. Kerr, president of the Oregon Agricultural College, at Corvallis on March 12, 1927. President Kerr is in hearty accord with the plan and promises financial aid from the college insofar as is possible.

Revision of Washington Service Rules

This subject was given consideration at the Seattle meeting April 15, 1927. A preliminary hearing on these rules was held by the Washington Department of Public Works in Olympia, Wash., on Sept. 9, 1926. From conclusions reached at that hearing the Department of Public Works formulated a final draft of the rules which was submitted to all power companies concerned with request for criticism to be submitted at the hearing in Olympia on April 28, 1927.

The power company executives favored a conference for the consideration of the rules. A joint report will be prepared. This meeting was held in Olympia April 27, 1927, the day preceding the hearing.

Fourth General Meeting, Engineering Section

The fourth general meeting of the Engineering Section of the Northwest Electric Light & Power Association was held in Portland, Ore., March 10 and 11, 1927. The address of welcome was presented by L. T. Merwin, vice-president and general manager, Northwestern Electric Company. Major H. S. Bennion, N.E.L.A. director of engineering, addressed the assembly on the afternoon of the first day and presented many items of interest covering activities at national headquarters. W. W. Briggs, vice-president and general manager, Grays Harbor Railway and Light Company, Aberdeen, Wash., addressed the meeting on the morning of the second day and discussed the necessity for co-operation between departments and the great importance of acquiring good-will of the public.

Each committee of the Engineering Section was alloted time on the program and presented many valuable papers which were discussed with a great deal of interest. The registration totaled 175 for the general meeting, demonstrating the increasing interest and value of these meetings.

Power Lines vs. Telephone Lines

A bill known as Senate Bill No. 107 granting right-of-way for telegraph and telephone lines and lines and wires conveying electric power was introduced in the Oregon Legislature on January 25, 1927. This bill as drawn was not satisfactory to the power companies and after several conferences the proponents of the bill withdrew it with the understanding that committees from the power companies and the telephone and telegraph companies would settle their difference through joint meetings of their respective committees.

This matter was discussed at the Seattle meeting of the executive committee on April 15, 1927. A committee consisting of H. H. Schoolfield, E. F. Pearson, Z. E. Merrill and H. R. Wakeman was appointed to handle this matter with the telephone and telegraph companies.

Franchises for Pole Lines on State Roads

Also at that meeting attention was called to action of the Washington State Highway Board in specifying clearances of wires above roads in a number of franchises recently granted. Franchises granted heretofore have been silent in this particular.

Clearances of 20 ft. for guys and 32 ft. for electrical conductors are specified in a recent franchise. If this standard were adopted generally it would increase the minimum cost of poles for rural distribution circuits about 33 per cent and would prove a serious handicap to rural distribution.

The practice of the Washington State Highway Board in requiring that poles be set only 1 ft. out from the edge of the road also was discussed. This results in crossarms overhanging private property and necessitates obtaining easements. In some cases such setting is necessary, but there are many miles of state roads where the poles could be set 5 ft. out from the margin of the road thus avoiding the overhang difficulty.

In Oregon the wire clearances are those specified by the National Electrical Safety Code, but the highway commission in that state is using the same standard as the Washington board with respect to setting poles 1 ft. from the margin of the highway.

This matter of wire clearances for highways also is involved in the hearing which is coming up in Idaho on June 27 covering the whole broad subject of an electrical construction code. This committee believes that action in the three states should be correlated and has called the matter to the attention of D. C. Green, president of the association, for such action as he may consider appropriate.

Accident Prevention*

During the year 1926-27 the work of the accident prevention committee has consisted mainly of co-operation with the national committee. The committee hoped to be able to submit a final report on the hay derrick hazard and the radio aerial hazard, but, owing to other work which required the attention of the chairman, no progress has been possible on these subjects.

A bill prepared by a committee of the Northwest Association of Electrical Inspectors in co-operation with the attorneys of the Portland Electric Power Company was introduced at the recent session of the Oregon Legislature. This bill proposed to make it unlawful for any person to attach an aerial or counterpoise to any line support on a public highway, or to erect or maintain an aerial or counterpoise either wholly or in part across any public highway.

No meetings of the committee have been held during the year except a luncheon-meeting of those members who were in attendance at the annual general meeting of the Engineering Section. All work has been done by correspondence. A meeting of the national committee was held during each of the two group meetings of the Engineering National Section. At the meeting in Chicago October 13-14, 1926, the chairman was represented by C. C. Simeral and at the February 4-5, 1927, meeting by D. W. Proebstel.

Result of National Inquiry

One of the first activities undertaken by K. R. MacKinnon as new chairman of the N.E.L.A. Accident Prevention Committee was to find out to what extent accident prevention work was being carried on by the N.E.L.A. member companies. To that end each divisional chairman was asked to secure the information for his division. F. J. Rankin, prior to his resignation as chairman of the Engineering Section, sent out a questionnaire to all the member companies as follows:

1. Are you doing accident prevention work?
2. Do you do this work through a safety supervisor?
3. Do you do this work through a safety committee?
4. How many workers do you employ?
5. To whom should accident prevention correspondence be addressed?

Table I shows the results of this inquiry in the Northwest Geographic Division:

An analysis of the reports from six of the N.E.L.A. geographic divisions showed that the percentage of replies received from companies solicited varied from 72 per cent to 33 per cent, the Northwest association

* **J. B. Fisken,** The Washington Water Power Company, chairman. **The California Oregon Power Company:** S. M. Bullis. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Idaho Power Company:** E. C. Kiersted. **Mountain States Power Company:** W. J. Mandley, Walter Smith. **Northwestern Electric Company:** J. R. Barfield. **Pacific Power & Light Company:** G. I. Drennan. **Portland Electric Power Company:** C. F. Young. **Puget Sound Power & Light Company:** E. H. Worthen. **Utah Power & Light Company:** F. E. Hansen.

being the lowest. The percentage of companies doing organized safety work varied from 93 to 56 per cent, the Northwest association again being the lowest.

Extract from N.E.L.A. Report

Later in the year, at the request of a sub-committee of the national committee, a questionnaire asking for details of accident experience was sent to every member company. Thirty-two answers were received. A preliminary report was submitted at the New York meeting in February from which Table II is extracted.

TABLE I—Answers to accident prevention questionnaire.

Method Followed	Number of Companies	Approximate Number of Employees
Did not reply to questionnaire	33	100
Not doing any safety work	4	610
Safety supervisor	3	2,800
Safety supervisors in conjunction with divisional or district safety committees	2	4,200
Safety committee in one state	1	325
Safety supervisor in two states		200
Methods not stated	3	1,400
	49	9,635

Accident Cost High

The compensation payments made by the companies in the Northwest association are deserving of attention. Compensation paid for both fatal and lost time accidents:

1923	$49,371.38
1924	$56,789.82
1925	$81,230.87

As these payments, with the exception of about $250.00 in 1923 and $200.00 in 1925, were made by nine companies it may be seen readily that accident cost contributes an appreciable amount to total operating costs. Since probably 90 per cent of the cost of accidents can be eliminated, and as premium rates for employers liability and state compensation are on the increase, the subject of accident prevention is deserving of more attention by company executives than it is receiving.

Recommends Records Be Kept

Practically every industry has an organization and holds meetings or conventions at which one company's experience can be compared with that of another. Such comparisons of accident experience should prove of great benefit in the Northwest association. In order that such comparisons can be made this committee urges that all member companies adopt a standard system for keeping their accident records, and recommends that the accident frequency rate and accident severity rate used be those adopted by the International Association of Industrial Accident Boards and Commissions.

The significance of and method of computing each rate is set forth below:

TABLE II—Extract from N. E. L. A. report.

	1923	1924	1925
Total employees of reporting companies	60,721	76,217	85,200
Total fatal accidents	102	133	152
Total lost-time accidents (excluding fatals)	6,248	8,408	8,162
Total days lost time (excluding fatals)	84,458	106,446	95,215
Fatal accidents per 1,000 employees:			
Northwest division	1.3	1.8	2.7
Average all reporting companies	1.7	1.8	1.8
Lost-time accidents per 100 employees:			
Northwest division	8.0	8.0	8.0
Average all reporting companies	10.3	11.0	9.6
Days lost per 100 employees:			
Northwest division	83	84	69
Average all reporting companies	139	140	112

1. **Accident Frequency Rate**—This rate is expressed in terms of the number of lost-time accidents per 1,000,000 man-hours worked. It is calculated by dividing the number of lost-time accidents by the millions of man-hours worked. For example, in a plant operating 20,000,000 man-hours in a year during which there occurred 600 accidents, the accident frequency rate would be:

$$\frac{600}{20 \text{ (Millions)}} = 30.0$$

2. **Accident Severity Rate**—This rate is expressed in terms of the number of days lost due to lost-time accidents per 1,000 man-hours worked. It is calculated by dividing the number of days lost by the thousands of man-hours worked. For example: In a plant operating 20,000,000 man-hours in a year during which there were 60,000 days lost, the accident severity rate then would be:

$$\frac{60{,}000}{20{,}000 \text{ (Thousands)}} = 3.0$$

In order that the severity rates may be figured on a uniform basis the scale of weights for deaths and permanent disabilities adopted by the International Association of Industrial Accident Boards and Commissions should be used:

Nature of Injury	Days Lost
Death	6,000
Permanent total disability	6,000
Arm above elbow, dismemberment	4,500
Arm at or below elbow, dismemberment	3,600
Hand, dismemberment	3,000
Thumb, any permanent disability	600
Finger, any permanent disability of	300
Two fingers, any permanent disability of	750
Three fingers, any permanent disability of	1,200
Four fingers, any permanent disability of	1,800
Thumb and one finger, any permanent disability of	1,200
Thumb and two fingers, any permanent disabiltiy of	1,500
Thumb and three fingers, any permanent disability of	2,000
Thumb and four fingers, any permanent disability of	2,400
Leg above knee, dismemberment	4,500
Leg at or below knee, dismemberment	3,000
Foot, dismemberment	2,400
Great toe, or any two or more toes, any permanent disability of	300
One eye, loss of sight	1,800
Both eyes, loss of sight	6,000
One ear, loss of hearing	600
Both ears, loss of hearing	3,000

A "lost-time" accident is one in which the injured employee loses time beyond the remainder of the shift on which he is injured.

Insull Medal Awards

That some of the member companies are interested in first aid work is evidenced by the award of Insull Medals to employees for successful resuscitation by the Shafer prone pressure method. During the association year two Insull Medals have been presented. On August 27, 1926, an Insull Medal was presented by Z. E. Merrill to Ted Montgomery of The California Oregon Power Company, who on March 30, 1925, saved the life of his helper, Andrew Folsom. The presentation was made at Klamath Falls, Ore., before an audience of nearly a hundred fellow employees and interested outsiders. On March 9, 1927, an Insull Medal was presented to Kenneth P. Sims of the Mountain States Power Company, who on May 22, 1926, successfully resuscitated his friend and foreman, R. E. Russell. The medal was presented to Mr. Sims at Albany, Ore., by J. B. Fisken before an audience of about one hundred employees and other interested persons. On March 11, 1927, Mr. Sims was presented by Z. E. Merrill to the members of the Engineering Section at the annual general meeting in Portland.

Prior to this association year the following employees of member companies have been presented with medals: Orville D. Lund, Utah Power & Light Company; Lee York, Utah Power & Light Company; Charles V. Catron, Utah Power & Light Company; Howard Dynan, The California Oregon Power Company.

Applications are pending before the national committee for the award of medals to Jack E. Woodhead and Frank C. Poage, both employees of the Idaho Power Company.

Women's Committee Activities Helpful

The committee desires to call the attention of the member companies to the activity which is being displayed by the various women's committees in the association along the lines of accident prevention and first aid work. This activity is gratifying to the accident prevention committee as undoubtedly it will assist the committee in its humanitarian efforts to save the lives and limbs of employees, and incidentally to save large sums of money to the companies.

Hydraulic Power*

The program of work as at first outlined was not carried out fully because several of the committee members found their time completely taken up with construction work, and could not take part in the committee activities.

This original program was as follows:

1. J. H. Siegfried was assigned the subject of "Silt Deposits and Methods of Elimination." Mr. Siegfried assembled some valuable data and presented a very creditable paper at the March meeting. This is a subject of considerable importance to most of the member companies, and it should be profitable to carry the study further.

2. C. P. Dunn was assigned the subject of "Pressure Tunnels." Some data has been assembled, but no report submitted. The P.C.E.A. sub-committee on "Pressure Tunnels" has asked us to join it in the preparation of a joint report during the 1927-28 season. This we have agreed to do tentatively.

3. E. H. Collins was assigned the subject "Paints for Hydraulic Uses" and "Economics of Load Distribution on Units." Mr. Collins was unable to prepare reports because of his time being fully taken up by the Chelan construction work. He no doubt has assembled some valuable data which can be made available at some future time.

4. J. A. Hale was assigned the subject "Evaporation from Reservoirs." Mr. Hale reported that he did not have sufficient data available to justify the preparation of a paper or formal report, and no report was submitted.

The following additional subjects were presented at the March meeting:

5. Ely C. Hutchinson, president, Pelton Water Wheel Company, San Francisco, submitted a paper on "High-Head Turbine Design." It is regretted that Mr. Hutchinson was unable to present the paper personally. It is to be hoped that during the coming year we will have an opportunity to get first hand his ideas on turbine design, with possibly a statement of operating experiences on some high-head units.

6. J. C. Stevens, consulting engineer, Portland, presented a valuable paper on "The Co-ordination of Power and Irrigation Interests," which was very ably discussed by D. C. Henny.

* **C. P. Dunn,** Portland Electric Power Company, chairman. **The California Oregon Power Company:** R. S. Daniels. **Idaho Power Company:** H. L. Senger. **Pacific Power & Light Company:** J. H. Siegfried. **Puget Sound Power & Light Company:** G. C. Sears. **Utah Power & Light Company:** J. A. Hale. **The Washington Water Power Company:** E. H. Collins.

Inductive Co-ordination*

Relations between the owners and operators of power wires and the owners and operators of communication wires in the territory covered by the Northwest Electric Light & Power Association have been uniformly satisfactory and have been practically undisturbed by inductive interference between the respective circuits. While there may have been some cases of interference, it is believed that these were of minor importance, as no cases whatever have been reported to the committee during the past year.

Not only have no problems presented themselves locally but there have been no requests from the national committee for data of any kind. Thus in reporting for the local committee there is nothing to be said as to its own accomplishments.

Work Of the National Committee

It is believed, however, that it will prove of interest to the membership of the association to survey briefly the status of the work in progress under the direction of the national committee, and to present here some of the more important decisions reached and principles developed as a consequence of the national committee's work.

The inductive interference committee was started nine or ten years ago, first as a sub-committee of the overhead systems committee, and then as an independent committee of the Technical National Section. The present name was taken a few years later. At the time the committee was established it was thought that three or four years might be required to bring its work to completion. This work primarily was to educate the power companies so that they could deal intelligently with the communication companies in inductive interference cases; to bring about a uniformity of policy and procedure on the part of the power companies in these cases and to develop principles upon which equitable settlements of disputes could be based.

Most of the foregoing has been accomplished, but it has been recognized that the committee's work never will be completed. It is a continuing work in a field which is constantly broadening; for example, witness the problems presented by radio interference and automatic train control, neither of which was thought of ten years ago as presenting any problems for the power companies.

The work of the national committee for a number of years has been prosecuted along five principle lines, each of which has been assigned to a major sub-committee. These are:

1. Allocation of costs.
2. Current cases.
3. Field surveys.
4. Radio.
5. Automatic train control.

A brief statement of the character of the work of each of these sub-committees and its present status therefore will afford the simplest way of summarizing the work of the main committee.

Allocation Of Costs

One of the most important subjects upon which the committee is working is the promulgation by the joint general committee of the N.E.L.A. and the Bell System of principles which should govern in dividing the cost of corrective measures between power and telephone companies. Before applying these principles the committee points out that "it is assumed the four following conditions will be met":

1. That each system has complied with the requirements for general co-ordination.

2. That the best engineering solution of the specific problem has been determined.

3. That the costs to be allocated are net costs and therefore exclude all items of betterment.

4. That the costs are computed on a uniform and mutually acceptable basis for both direct and indirect charges.

The basis of allocation of costs then should be:

1. Each utility at its own expense should design, construct, operate and maintain its plant in accordance with general co-ordinated methods.

2. Specific methods of co-ordination should be paid for by such equitable apportionment of the costs as may be agreed to by the utilities affected. It may be found reasonable in some cases for each party to bear the costs of such specific methods of co-ordination as result in net capital additions in its own plant; care must be exercised, however, that this be not carried to a point where the best engineering solution is prejudiced. In cases where it is not clear as to what constitutes an equitable apportionment a "50-50" division of the costs may be found the most practicable solution.

3. All carrying charges, repair operating or other current expenses incident to specific co-ordinated methods and all subsequent replacement costs arising after and due to the installation of specific co-ordinated methods should be borne by the utility on whose system the costs are incurred.

The committee points out that:

The above outlined plan has the advantage that it can prejudice in no way the application of the best engineering solution because it gives each party a direct interest in reducing the total cost of specific co-ordinated methods rather than in whether or not the expense is incurred in one plant or the other or both.

The foregoing principles of allocation of cost, while leaving a good deal to be desired, nevertheless are a long step forward and undoubtedly will be useful and pave the way for a more complete and seasoned method of procedure.

* **G. E. Quinan,** Puget Sound Power & Light Company, chairman. **Grays Harbor Railway & Light Company:** H. J. Flagg. **Northwestern Electric Company:** L. H. Kistler. **Pacific Power & Light Company:** H. H. Schoolfield. **Portland Electric Power Company:** W. R. Cornell. **Puget Sound Power & Light Company:** E. L. White. **Utah Power & Light Company:** C. H. Higson. **The Washington Water Power Company:** J. B. Fisken, E. V. Olson.

Current Cases

The sub-committee on current cases has had submitted to it to date a total of approximately 400 cases in which assistance was asked by member companies of the association in negotiating settlements with the communication companies. The sub-committee has rendered signal service in this connection not only by giving advice and making available the extensive bibliography which has been accumulated at headquarters, including a very comprehensive digest of decisions in interference cases, but by placing at the disposal of various companies the services of the headquarters' staff of technical experts. In some cases these experts have assumed the direction of the preparation of the companies' cases before courts or commissions, and have acted as expert witnesses in proceedings.

The sub-committee reports for the past year that there has been a marked decrease in the number of new cases. This indicates either that the power companies are handling these cases themselves without having to ask assistance, or that the better perspective on interference which now prevails with both the power companies and telephone companies is resulting in more attention to the proper co-ordination of wire facilities at the time they are constructed and reconstructed, so that interference disputes are actually becoming less in number.

Field Surveys

In order to obtain some notion of the extent of the interference problem throughout this country and to determine also the percentage of parallels which have given trouble the sub-committee on field surveys for the past five years has been collecting detailed information on existing parallels between power and communication circuits. These data now are being analyzed and digested and will afford the first comprehensive basis for determining the extent to which parallels between the two classes of service have resulted in serious trouble.

Radio and Train Control

These are two new uses of the ether involving apparatus of extreme sensitiveness which in some cases has proved so susceptive to stray magnetic fields as to be seriously interfered with.

Interference of power circuits with radio reception has been discussed so widely as to be fairly familiar to all. Without intelligent handling radio interference might well have become a serious problem for the power companies. Fortunately for the industry the inductive co-ordination committee was well organized to understand and cope with the situation and the radio sub-committee has rendered good service in educating the radio dealers, the radio press and the public to a proper understanding of the causes back of radio interference.

Automatic train control has been ordered by the Interstate Commerce Commission to be put into effect on some 15,000 miles of railroad in this country, involving a total of 129 roads. This type of train control is for the purpose of automatically stopping or controlling the speed of trains to avoid collision. It seems probable that it will be widely used eventually.

Some of the types of control systems are fairly immune to the influence of magnetic fields of power lines. Others are very sensitive indeed and tests indicate that induced effects from 66-kv. lines carrying approximately 350 amp. per phase were of sufficient magnitude to affect seriously the operation of the train control system up to a distance of 250 ft. from the power line.

The train control sub-committee in its March, 1927, serial report presents a very clear-cut review of the situation and suggests what may prove to be an effective remedy: the employment in train control systems of frequencies higher than 60 cycles.

Overhead Systems*

Efforts of the overhead systems committee for the year 1926-27 have been concentrated on three important studies.

Tests of Insulator Testing Equipment

The first of these studies has been made by Professor F. O. McMillan in the high-voltage laboratory at the Oregon Agricultural College, Corvallis. It consisted of comparative tests on live-line, high-voltage-insulator testing equipment. The equipment or "sticks" of various manufacturers, inculding the Doble, Iler, and Johnson types, were tested. High-voltage insulators of various manufacturers, including both pin-type and strain-type were used for the tests. These insulators were furnished by the various member companies and had been taken out of service on lines because of more or less pronounced defects. The tests were made by senior students in Electrical engineering at the college. Because of the number of men testing, a comparison could be made of the results of several men testing the same insulator with different equipment.

Fire-Killed Poles

The second study was made because of the feeling that the subject of life and use of poles was so important that no year should go by without some contribution from this committee towards the knowledge of the subject. Also because of the strenuous efforts being made to extend lines into rural territory and the very evident need for low cost of such lines, anything which might tend to lower such cost is of definite interest. Consequently a study of the use of fire-killed poles was made by L. R. Gamble. The important result of Mr. Gamble's study seems to be the determination that the delivered price of poles probably would be affected less than 5 per cent regardless of whether poles were cut from growing timber or from fire-killed trees.

Standardization

The third study was made by H. R. Wakeman on the subject of standardization of distribution-line materials and methods. His paper and subsequent discussion brought out the value of rather strict standardization for greater safety and economy. Views expressed by representatives from purchasing and stores departments were very valuable in bringing out all sides of the question.

The request made by H. C. Sutton, chairman of the N.E.L.A. overhead systems committee, that minutes of meetings of this committee in various geographic divisions be sent to all the geographic representatives on the national committee has resulted in a great deal of good. In the Northwest division, due to the great distances between headquarters of member companies, no meetings are held except at the time of the annual general meeting of the Engineering Section. No minutes therefore are avialable from this division.

This committee was represented at the Chicago meeting of the N.E.L.A. overhead systems committee on Oct. 13 and 14, 1926, by M. T. Crawford.

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* **T. A. Purton,** Idaho Power Company, chairman. **The California Oregon Power Company:** C. D. Wood. **Eastern Oregon Light & Power Company:** J. B. Brokaw. **Graybar Electric Company:** H. J. Billica. **Grays Harbor Railway & Light Company:** F. J. Robbins. **Idaho Power Company:** H. M. Jones. **Mountain States Power Company:** L. W. Edwards. **Northwestern Electric Company:** D. A. Hord. **Oregon Agricultural College:** F. O. McMillan. **Pacific Power & Light Company:** R. J. Davidson. **Portland Electric Power Company:** H. R. Wakeman. **Puget Sound Power & Light Company:** M. T. Crawford, C. L. Hill. **Utah Power & Light Company:** P. P. Ashworth. **The Washington Water Power Company:** L. R. Gamble.

Underground Systems*

Four major subjects were studied by the underground systems committee during the current year. Papers were presented on three of these subjects at the Engineering Section meeting held in Portland March 10-11, 1927.

Submarine Cable Installation and Repairs

A paper on this subject was presented by M. T. Crawford and C. H. Hoge. This paper deals principally with methods and equipment used in laying power cables from two to four miles in length in water depths of from 350 to 850 ft. The paper points out that the greatest problem in laying long cables is that of avoiding extreme tension on the cable. This problem is solved through the use of proper continuous cable-laying equipment with adequate braking facilities. The paper describes in detail the proper apparatus for this work.

Conduit and Manhole Construction and Ventilation

This paper was presented by J. M. Gillham and S. B. Clark. It stresses the necessity of proper planning for the future in laying out an underground system. A recommendation is made that one individual in the engineering department should be charged with the responsibility of compiling data and forecasting future loads by districts so that snap judgment may be eliminated and the proper economic construction balance maintained. The paper compares the characteristics of various types of ducts and general methods of duct-line construction. A new type of directed forced ventilation for transformer vaults is described. This plan makes use of cast-in air ducts in the floor of the vaults. Motor-operated blowers, thermostatically controlled, force the air direct to transformers. By properly distributing the air around the transformer case it is possible to use from 25 to 35 per cent less air than in an indirect system.

Corrosion of Cable Sheaths

This paper was presented by John S. Volpe, engineering department, Portland Electric Power Company. Considerable corrosion has occurred and a white lead formed on the sheath of cables in wooden ducts buried in sawmill refuse in a fill. Through laboratory experiments it was found that decaying refuse and moisture from acetic acid which attacks the lead and forms lead acetate. It is recommended that ducts installed in refuse fills be well drained and ventilated, and that the cable sheath be painted with asphalt paint.

Installation and Operation of Overhead Lead-Covered Power Cables

This subject is being investigated through questionnaires by the chairman of the committee. A majority of power companies use only limited amounts of this type of construction. Several installations of 4.1-kv., 3 and 4-conductor cable are in operation with no serious operating difficulties reported. Short lengths of 11-kv. and 13-kv. cable are in operation with some trouble experienced through cracking of the splice sheath due to vibration and injury caused by rocks thrown at the cable. One installation of 33-kv. cable was operated eight months, but after several failures the installation was removed. The theory was advanced that the wide range of operating temperature was responsible for the trouble.

In most cases detail of construction is similar to that used by the American Telephone and Telegraph Company.

* **E. F. Pearson,** Northwestern Electric Company, chairman. **Idaho Power Company:** T. A. Purton. **Northwestern Electric Company:** S. B. Clark. **Portland Electric Power Company:** J. M. Gillham. **Puget Sound Power & Light Company:** C. H. Hoge. **Utah Power & Light Company:** P. P. Ashworth. **The Washington Water Power Company:** F. L. Rohrbach.

Public Relations Section Committee Reports

Executive*

During the association year 1926-27, the activities of the Public Relations Section were carried on by two committees—the committee on co-operation with educational institutions and the women's committee.

No committee on public speaking was formed, it having been decided to carry on public speaking activities under the supervision of the vice-presidents of the various states.

During the past year the public utility companies have been very successful in having speakers introduced before all kinds of gatherings of people. The company executives have taken a great interest in presenting the problems of the utility companies to the people in the territories served by the various companies. All persons connected with public utility organizations who are familiar with various phases of public utility service have been urged to keep in mind the possibility of addressing various clubs and meetings upon subjects in line with their work or with which they are familiar, and to hold themselves ready on reasonable notice to make such talks.

Results in Public Speaking

Some of the companies carried out the organization plan recommended by the national committee, while others did not. This plan was carried out in the state of Idaho, where various organizations of the state who put on regular programs were acquainted with the possibility of securing speakers from the state committee to address them on various branches of public utility service, and to a considerable extent these organizations availed themselves of the opportunity and many addresses which were made resulted directly from this plan of action.

In the Northwest geographic division there were talks made before civic bodies, clubs, and various meetings during 1926, as follows:

	Talks	Approx. Attend.
State of Idaho:		
Idaho Power Company	50	5,000
State of Oregon:		
Pacific Power & Light Company	42	5,300
Mountain States Power Company	38	3,050
State of Washington:		
Puget Sound Power & Light Company	1,000	100,000
Washington Water Power Company	25	3,000
State of Utah:		
Utah Power & Light Company	80	4,500

No report was received from Montana, nor were reports received from all of the utilties in the state of Oregon.

Committee on Co-operation with Educational Institutions

This committee, under the leadership of R. B. Bragg, chairman, continued the worthwhile activity commenced last year of making lectures on public utility subjects available at the Universtiy of Idaho and the Washington State College. In addition the committee took steps to have regular public utility

* **R. M. Boykin,** Puget Sound Power & Light Company, chairman. **Marguerite Butler,** Portland Electric Power Company, chairman women's committee. **R. B. Bragg,** Pacific Power & Light Company, chairman committee on co-operation with educational institutions. **R. B. King,** Idaho Power Company, vice-president for Idaho. **W. B. McDonald,** Mountain States Power Company, vice-president for Montana. **G. L. Myers,** Pacific Power & Light Company, vice-president for Oregon. **P. M. Parry,** Utah Power & Light Company, vice-president for Utah. **N. W. Brockett,** Puget Sound Power & Light Company, vice-president for Washington.

courses installed in some of the colleges and universities in the territory, and recommended that next year's committee continue the work started so that the matter may be carried to a successful conclusion.

Women's Committee

The women's committee headed by Miss Marguerite Butler, chairman, has been very active during the year and spendid results have been accomplished in creating better public relations, advancing public information and in the education of public utility women.

Reports which give a very complete resume of the activities of each of these two committees during the associtaion year, have been prepared by the chairmen.

Co-operation With Educational Institutions

Work Accomplished

Lecturers were made available at suitable times during the past year at the University of Idaho and at Washington State College, continuing a program instituted by last year's committee. These lecturers were from the personnel of member companies and more than one speaker was arranged for who was prepared to treat each subject so that there were no delays or postponements due to the lecturer being unable to appear at the assigned time.

The following lectures were offered to the above colleges each of which was prepared by a different individual:

General Economics of the Public Utility Business.
Indeterminate Permits in Lieu of Fixed Term Franchises.
Phases of Government Regulation as Applied to the Public Utility.
Engineering Phase of Public Utility Operation.
Control of Migratory Fish.
Public Utility Valuation and Rate Making.
History and Development of the Electrical Industry.
Rates.
History of Electrical Service.
Regulation of Public Utilities.
Present Electrical Development in the United States in its Relation to Public Welfare.
Rate Making of Public Utilities.

New Work Started

This committee felt that the success of the work carried on at the University of Idaho and Washington State College warranted extending this field of activity, looking toward the establishment of definite courses in all of the principal colleges and universities in the Northwest association's geographic area. It was felt that a definite course on the subject of "Public Utilities" would be an improvement over a mere series of lectures.

With this idea in mind members of the committee conferred with engineering college deans at the various institutions, who, in turn, discussed the matter at their faculty meetings. The deans were found to be generally very responsive. The catalogs of these institutions were analyzed as to the subjects now offered for study and it was found that a comprehensive public utility course would in most cases fit in very satisfactorily.

The preliminary general conclusions arrived at were as follows:

1. The institutions would recommend the establishment of comprehensive utility courses.
2. If the association will supply suitable lecturers and provide for their presenting a reasonable number of prepared lecturers, the institutions will provide instructors for conducting several classes per week which will be in the nature of quizzes on the lectures and further presentation of details of the subject.
3. Engineering graduates who have elected to take the public utilities course would be better fitted for entering the service of member companies and it was hoped that arrangements could be made for the larger companies to take one or more of such graduates each year into their employ.
4. In order to put into effect this proposed program, some definite arrangements will have to be made for the financing of the time and expense of lecturers necessary. It is the earnest recommendation of this committee that steps be taken by the executive committee to provide the necessary financing plan so that the matter may be carried to successful completion while it is still favorably looked upon by the educators.

Recommendations for Future Work

It is recommended that the following program be carried out by the succeeeding committee:

1. Immediate completion of arrangements for financing the appearance of lecturers at least at a few of the larger universities.
2. Following this the detailed plan of courses to be offered and the co-ordination of lectures and classwork should be decided on in conference with the educators.
3. Steps should be taken to encourage the taking of these courses by the students by means of arranging to secure employment of a few of each year's graduates.

* **R. B. Bragg,** Pacific Power & Light Company, chairman. **Idaho Power Company:** J. L. Boone. **Mountain States Power Company:** Z. E. Merrill. **Puget Sound Power & Light Company:** M. T. Crawford. **Utah Power & Light Company:** E. L. Bourne. **The Washington Water Power Company:** W. H. Ude.

Women's Committee*

During the past year the women's committee has endeavored to follow the program outlined by the national committee, which stresses particularly correct house wiring, home lighting, and the use of all household electric appliances, but at the same time adapting that program, which is elastic in intent, to suit local conditions. The purpose has been to know our own companies better; to learn more about the industry as a whole; to find our daily work more attractive with this increased knowledge; and, with knowledge and happiness combined, to increase friendly feeling on the part of the public through daily contacts such as every woman has with her friends and acquaintances. The keynote of the national program is that public satisfaction with utility service is dependent upon the understanding every employee possesses of the service the utility is giving of the utilization of that service, and of the industry's aims; and upon a proper manner being maintained by utility representatives toward the public. Therefore, well informed utility women, with the many opportunities they have for disseminating information both in and out of the office, are valuable public relations assets. The women's committee is trying to make its members better informed.

Thirteen Committees Now Functioning

At the beginning of the association year there were ten women's committees organized and active; now at the close of the year there are thirteen committees actively participating in the work. Eleven of these committees are formed in utility companies, one including the local supply companies in with its activities. Two communities consist of supply companies only.

The women's committee held its first meeting of the association year in Portland, on Oct. 18, 1926. The

* **Marguerite Butler,** Portland Electric Power Company, chairman. **The California Oregon Power Company:** Mildred Knight. **Deschutes Power & Light Company:** Minnie C. Johnson. **General Electric Company:** Martha O. Goldapp. **Graybar Electric Company:** Dorothy Nixon. **Grays Harbor Railway & Light Company:** Esther Miller. **Idaho Power Company:** Mrs. Gertrude McDevitt. **Mountain States Power Company:** Stella Dorgan. **Northwestern Electric Company:** Mrs. A. W. Angell. **Pacific Power & Light Company:** Ella McCurdy. **Puget Sound Power & Light Company:** Mrs. Neil Laws.. **Utah Power & Light Company:** Mrs. A. E. Moyle. **The Washington Water Power Company:** Mary K. Walsh.

chairman made a report covering her trip to Chicago where she attended a meeting Oct. 4-5 of the national women's committee, several things having been brought up at that meeting which offered suggestions for the work of the Northwest committee. Reports, with round table discussions, covering work done in each company, were given by all members who had active committees the past year. It was also suggested at this meeting that all companies make an effort to place appliances in the homes of the employee; that an inquiry be made to find out whether electric appliances which our customers own are being used to the fullest extent or whether, when an appliance does not work properly, it is stored away with a feeling of enmity instead of being reported and repaired (such a condition being said to exist in the East); that the committees use in their meetings some of the motion pictures prepared and distributed by the General Electric Company; that each chairman become a member of the N. E. L. A.

Special Subjects Studied

The second meeting was held in Boise, Feb. 21, 1927. Reports were given by the three study groups formed at the previous meeting, as follows. The "Personnel Problem" group has been furnished a list of reading material, the study of which it is felt will give the women a greater understanding of problems which are constantly arising in their work, it being believed that the women's committee can grow only as fast as the chairmen increase their own knowledge and ability. The members of the group formed to study "Programs for Smaller Companies" have been in correspondence with each other and are endeavoring to exchange ideas which will be helpful in planning their programs. The group considering "Closer Co-operation with Women's Clubs" offered many excellent and practical suggestions.

Committees Hold Monthly Meetings

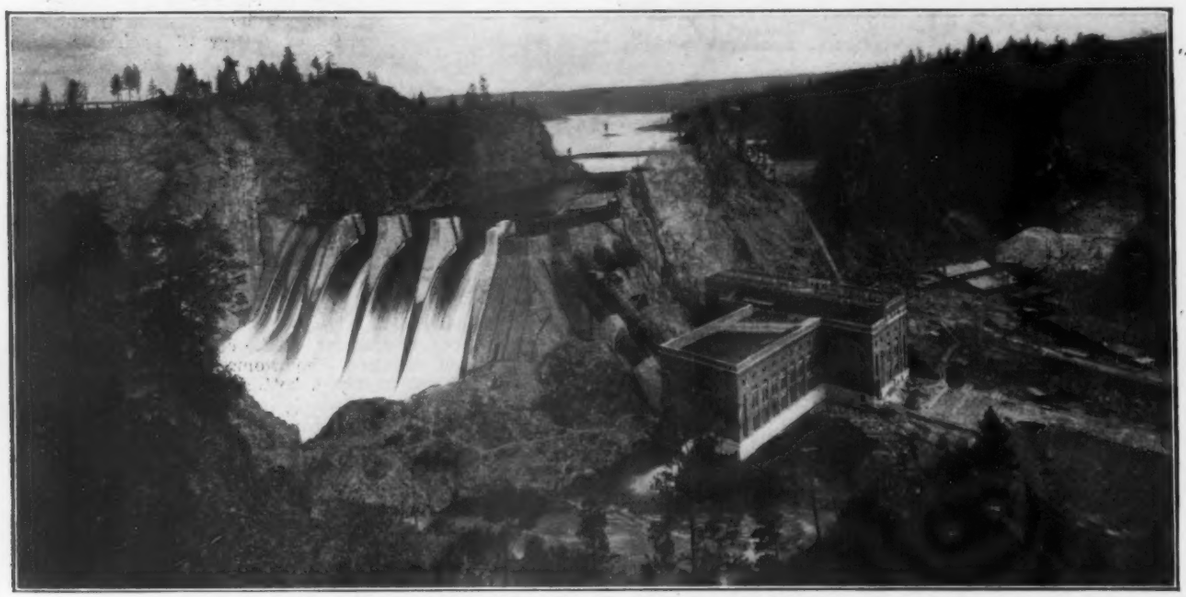
The group reports completed, each member gave a report of committee work done and other activities engaged in since the Portland meeting. Discussion followed each report. Each committee has held monthly educational meetings. Programs consisted of talks or papers given by department heads or the women themselves on various phases of the public utility business such as transmission, public service commission, home lighting, customer ownership, rates, electrical appliances, safety, first aid, public relations, public ownership, various departments of individual companies, the presentation of G. E. motion pictures and playlets on utility subjects, furnshed by N.E.L.A. headquarters.

Miscellaneous Activities

In addition to the subjects studied at the monthly meetings since October, the chairmen and their committee have been active in several other ways. For instance, the Oregon committees feel that their members are entitled to part of the credit for the result of the state ownership election in November, the women employees being well informed on this subject through the medium of the committee work. Many of the committees have formed first aid classes. A few talks have been given, or papers read, on utility subjects to groups outside the industry, and one radio address has been given. Several of the committees have presented utility playlets before their companies' clubs. The value of athletics in making the women employees happier and better acquainted, and also mixing with groups from other organizations, has not been overlooked, some of the committees having organized basketball, gymnasium, tennis, baseball and golf groups. Dramatic clubs have also been found to be an excellent way to arouse interest. All members of one committee are studying "What Every Club Woman Ought to Know" with the hope of being more useful to clubs in that territory. One committee turned its monthly meeting over to the local community chest. Two of the committees have girl resuscitation teams that are appearing before outside groups. One essay contest has been held in this period on the subject "How to Sell Our Company to Our Customers." Many of the chairmen are now active members of from one to five women's clubs in their territories; some hold important offices in such clubs, and are placing utility speakers on the programs.

Four of the committees have included the wives of the utility men in their committee organization. In three of them the employees and the wives function as one group; the fourth committee handles the wives in a group entirely separate from the employees, but with the same chairman and having similar programs.

The women's committee believes it is justifiably proud of the past year's work and, indeed, the result could scarcely have been otherwise considering the excellent personnel which the chairman has been so fortunate as to possess. With continued co-operation on the part of the executives, there is an unlimited field for future accomplishments in the way of advancing public information and satisfactory relations through utility women.



Long Lake Plant, The Washington Water Power Company.